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B.C. HYDRO AND POWER AUTHORITY
COLUMBIA RIVER
RESERVOIR COORDINATION STUDIES

ENVIRONMENTAL IMPACT ASSESSMENT

FINAL REPORT

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EXECUTIVE SUMMARY

The British Columbia Hydro and Power Authority (BCHPA) is presently negotiating a reservoir coordination agreement with Bonneville Power Administration (BPA) to utilize the storage of water in reservoirs controlling the Columbia River, beyond that covered under the existing Columbia River Treaty and the existing Non-Treaty Storage Agreement. This summary report has been produced as a background document for public information and discussion on the proposed changes in reservoir operation.

The intent of a new agreement for use of non-treaty storage is to optimize power generation over the whole length of the Columbia River within licence and power transmission restraints. Currently, 2.47 x 10^9 m^3 (2.0 million acre feet (MAF)) of Mica Reservoir non-treaty storage is being utilized under the present Non-Treaty Storage Agreement, which expires in 1993. BCHPA proposes to make an additional 3.71 x 10^9 m^3 (3.0 MAF) of non-treaty storage behind Mica Dam available for use under the proposed new agreement. This water can be used to generate additional hydroelectric energy at both Mica and Revelstoke Dam generation facilities as well as at U.S. facilities along the Columbia River.

This report summarizes the findings of an assessment of the potential environmental impacts of four alternate reservoir operating regimes, including effects on water quality, fish, wildlife, heritage resources, and water-based uses relating to settlements, forestry, agriculture and recreation in the areas adjacent to Mica and Arrow Lakes Reservoirs. Each regime was compared to an associated base case. The comparisons were selected to bound potential impacts and determine the sensitivity of resources to each regime. Actual operation is likely to be a combination of or variation on these basic regimes at different times during the agreement. Each regime utilizes the total non-treaty storage (6.18 x 10^9 m^3 (5.0 MAF)) behind Mica Dam and tests, in order, different assumptions for energy loading scenarios including medium loads and opportunity energy sales (Regime 1), changes in energy production priorities, termed Alternate Resource Order (Regime 1, ARO), more active marketing of energy, termed Alternate Operating Scenario (Regime 1, AOS) and firm energy sales (Regime 2).

Physical data on the alternate reservoir operating regimes were supplied by BCHPA in conjunction with BPA, consisting of statistical distributions of monthly reservoir elevations and outflows from Mica and Arrow Lakes Reservoirs. These data were subsequently put into graph and summary table format by Triton Environmental Consultants Ltd. for use in the comparative analyses. The statistical data were generated by BPA's System Analysis Model (SAM), which simulated operation of the U.S. Pacific Northwest and B.C. power systems on a monthly basis.

Environmental Resources and Resource Uses

Mica Reservoir

Mica Reservoir is licensed to be operated between a minimum elevation of 707 m (2320 ft) and a maximum elevation of 754 m (2475 ft) (an operating range of 47 m (155 ft)). It currently is operated between approximately 735 m (2411 ft) and full pool. The reservoir is a deep, cold, nutrient-poor lake, with low biological productivity. Rainbow trout, kokanee, Dolly Varden char and Mountain whitefish are the most important and abundant sport fish. Due to the steepness of the slopes above the reservoir and in the drawdown zone itself, Mica Reservoir does not provide good habitat for most species of wildlife. Most waterfowl use occurs in the few areas of flat or gently-sloping shoreline around the reservoir.

Forestry is the dominant resource industry in the region and large areas of Crown Land near the reservoir are held under various forest tenures. Valemount and Golden are the major employment, transportation, retailing and service centers for the region. None of the communities in the area utilize the reservoir as a water supply source.

Poor soils, a short growing season and distance to markets severely limit agricultural activity in the Mica Reservoir area. Recreation activity on and around the reservoir is light and confined mainly to the local population, although use has been slowly increasing over the years.

Arrow Lakes Reservoir

The Arrow Lakes Reservoir extends from Revelstoke in the north to Castlegar in the south. The reservoir presently has a minimum elevation of 420 m (1378 ft) and a normal maximum elevation of 440.1 m (1444 ft), an operating range of 20 m (66 ft).

The Arrow Lakes Reservoir is deep and has fairly low biological productivity, although it is slightly more productive than Mica Reservoir. Rainbow trout, Dolly Varden char and kokanee are the principal sport fish. The Arrow Lakes occupy a deep north-south oriented valley which forms a natural migration route for many birds during spring and fall. The species of importance are primarily waterfowl and other aquatic/wetland species.

The largest communities are Revelstoke at the north end of Upper Arrow Lake, the City of Castlegar at the south end of Lower Arrow Lake, and Nakusp near the Narrows area. None of the communities except Castlegar use the reservoir as a source of water supply.

Forestry sustains most of the labour force in the area. The majority of land surrounding the reservoir is within Tree Farm Licence (TFL) #23 and provides logs to area sawmills. The majority of the logs go to Westar Timber's sawmill just north of Castlegar. The Celgar Pulp and Paper Company operates a water intake just upstream of Hugh Keenleyside Dam which supplies process and drinking water to its pulp mill near Castlegar, the Westar sawmill, and drinking water to Castlegar itself.

At present, there is limited agriculture in the Arrow Lakes area, mostly in the vicinity of Edgewood, Nakusp and Burton.

The Arrow Lakes Reservoir is large, scenic and more accessible than Mica Reservoir, and provides numerous recreation opportunities. Recreational use by both residents and tourists is increasing.

Downstream Area

Flows released from Hugh Keenleyside Dam control Columbia River water levels in the reach upstream of the confluence with the Kootenay River. Flows are greatest during winter in response to downstream water demands and decline to a low in March-April. The river provides resident fish with year-round, mostly open-water habitat with high rearing potential. Rainbow trout, kokanee, Dolly Varden char, whitefish and burbot are the principal sportfish species. Because the flows are controlled and the spring freshet has been reduced, the river provides relatively stable habitat conditions for aquatic/riparian wildlife although riparian habitats are of limited extent. Relatively small numbers of birds, primarily migrants and wintering birds, utilize the river.

Trail is the largest community downstream of Castlegar and is the location of Cominco's large smelter, refinery and fertilizer complex. Cominco uses water from the river for its smelting and fertilizer complex at Trail and the Village of Warfield (population 1840) and the Tadanac subdivision of Trail also obtain their water from this intake. Effluent from these industrial complexes and from Castlegar's sewage treatment facility is discharged to the Columbia River. The major industrial user of the river, other than as a source of water, is the Westar Timber Corporation, which stores logs on the river prior to transporting them by water into its sawmill.

There is very little active agriculture in the vicinity of the Columbia River.

The river is considered to have moderate recreation capability. At present, there are few developed recreation facilities. The river is mainly used for recreation by regional residents.

Impact Assessment

Physical Effects

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

With Regime 1 (medium load), the average elevation of the Mica Reservoir decreases during all times of the year, and the annual operating range increases by up to 6.4 m (21 ft) compared to the Base Case (medium load).

In the Arrow Lakes Reservoir, the annual average elevation difference between Regime 1 and the Base Case (medium loads) is 0.07 m (0.3 ft). Average elevations range from a decrease of 0.03 m (0.1 ft) in March, to an increase of 0.2 m (0.7 ft) in early April.

Average outflows from Hugh Keenleyside Dam increase in August through December and decrease January through July. With Regime 1, the highest average flow increase (235.7 m^3/s (8322.1 ft^3/s)) occurs in September, while the highest average flow reduction (116.8 m^3/s (4124.5 ft^3/s)) occurs in April.

Regime 1 (ARO) Compared to Base Case (ARO)

Under Regime 1 (ARO), the average elevation of the Mica Reservoir decreases, and its annual operating range increases by up to 6.7 m (22 ft) compared to the Base Case (ARO).

In the Arrow Lakes Reservoir, the annual average elevation difference between Regime 1 (ARO) and the Base Case (ARO) is 0.03 m (0.1 ft). Average changes in elevation range from no change in March, and June through August, to a 0.12 m (0.4 ft) increase in late April. No changes in maximum and minimum elevations will occur.

Average outflows from Hugh Keenleyside Dam generally increase in August through December and decrease in January through July, compared to the Base Case (ARO). With Regime 1 (ARO), the highest flow increase (225 m^3/s (7944.5 ft^3/s)) occurs in September, while the highest flow reduction (123.3 m^3/s (4354.7 ft^3/s)) occurs in late April.

Regime 1 (AOS) Compared to Base Case (AOS)

Under Regime 1 (AOS), the average elevation of Mica Reservoir decreases and its annual operating range increases by up to 7.8 m (25.6 ft) compared to the Base Case (AOS).

In the Arrow Lakes Reservoir, the annual average elevation difference between Regime 1 (AOS) and the Base Case (AOS) is 0.07 m (0.22 ft).

Average outflows from Hugh Keenleyside Dam generally increase in August through December, and decrease in January through July, compared to the Base Case (AOS). With Regime 1 (AOS), the highest average flow increase (215 m^3/s (7591.7 ft^3/s)) occurs in September, while the highest average flow reduction (108.5 m^3/s (3833.1 ft^3/s)) occurs in late April.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Under Regime 2 (medium load), the average elevation of the Mica Reservoir decreases at all times of the year, and the annual operating range increases by up to 3.4 m (11.1 ft) compared to the Base Case (medium load).

In the Arrow Lakes Reservoir, the annual average elevation of the reservoir with Regime 2 (medium load) decreases by 0.03 m (0.1 ft) compared to the Base Case (medium load).

Average outflows from Hugh Keenleyside Dam generally increase in August through January, early April and June, and decrease in February, March, late April and May, compared to Base Case (medium load) outflows. Under Regime 2, the highest flow increase (101.0 m^3/s (3565.4 ft^3/s)) occurs in September, while the highest flow reduction (80.4 m^3/s (2839.4 ft^3/s)) occurs in February.

Biological Effects

Water Quality

The only area where water quality is a concern at present is the reach of the Columbia River downstream of Hugh Keenleyside Dam, due mainly to the effects of the Celgar pulp mill effluent. As the Celgar pulp mill near Castlegar will be required to comply with B.C. guidelines for effluent toxicity by 1991, future water quality will be improved compared to what it is today.

Fish and Fish Habitat

Mica Reservoir

The capability to predict the effects of water-level changes on aquatic biota in lower trophic levels is poor, however, changes in plankton production can be expected with implementation of any of the regimes. The generally lower reservoir levels should not adversely affect access to tributaries by spawning fish, except in three rivers. Migration barriers on the Wood and Beaver Rivers and Foster Creek would be exposed at various times with all regimes. The extent and severity of this potential impact is difficult to assess since the proportion of the total fish population utilizing the three streams for spawning and rearing purposes is not known. However, it is likely that these three streams only contribute between 5 and 10% of the overall fish production of the reservoir.

The current drawdown zone does not provide productive fish habitat. Therefore, it is unlikely that reduced overall reservoir levels will have any effect on the amount of available rearing habitat in the reservoir or its tributaries. Due to the steep-sided slope of the reservoir and the effects of drawdown, shoreline spawning is already extremely limited and would remain so under both base case and alternate regime conditions.

Arrow Lakes Reservoir

For all regimes, the projected Arrow Lakes Reservoir elevations are very similar to the associated base case elevations. Increased entrainment of plankton, benthic invertebrates and fish from the Arrow Lakes during periods of rapid discharge is not expected to significantly affect the biological productivity of fish resources of the Arrow Lakes Reservoir. Overall, there are no anticipated impacts on fish utilizing the Arrow Lakes Reservoir.

Downstream Area

The different regimes will result in elevated outflows during August to December from the Arrow Lakes Reservoir compared to the base cases. There will likely be minor beneficial effects downstream of the Hugh Keenleyside Dam as increased outflows result in increased numbers of juvenile fish and invertebrates from Lower Arrow Lake being entrained over the dam to the downstream area.

Decreased outflows from Hugh Keenleyside Dam during the period January through July would result in small decreases in overall discharge in the Columbia River downstream of the dam which, in turn, could adversely affect important sport fish rearing and/or spawning habitat in the Columbia River below Hugh Keenleyside Dam. Eggs deposited during the high water period may become exposed when late winter - early spring downward fluctuations in water depth occur.

Wildlife Resources

Mica Reservoir

At present, variations in reservoir level, combined with other factors such as steepness of terrain, severely limit production of aquatic/wetland wildlife at Mica Reservoir. Therefore, increased annual ranges in reservoir level due to any of the reservoir operating regimes would have little incremental effect compared to the associated base cases. Generally lower reservoir levels at times when waterfowl, shorebirds and other species are migrating along the Rocky Mountain Trench should have no adverse impact because those birds primarily rest on sandbars and mudflats and such habitats will still be available.

Arrow Lakes Reservoir

With all regimes, differences between Arrow Lake elevations and the associated base case conditions are small. Slight, if any, incremental impacts on wildlife habitat or on waterfowl occurrence will result.

Downstream Area

With the alternate reservoir operating regimes, differences in average monthly outflows from Arrow Lake Reservoir compared to their associated base case flows are slight. Resulting changes in water depth and channel width in the Columbia River will be minor and are expected to have no measurable impact, positive or negative, on wildlife habitats or populations along the river.

Resource Uses

Forestry

Mica Reservoir

The problems forest companies experience with fluctuating reservoir levels, particularly with low levels, during June through October when water-based forestry activities occur on

Mica Reservoir, will be exacerbated if any of the regimes are implemented. As average elevations are substantially lower with Regime 1 (AOS) than with any other proposed operating regime, this regime will generally have the greatest impacts on forest industry activities in the area. With lower elevations, some barge points, log dumps and dewatering sites will require modification by lengthening ramps and skids, which would add to operating and maintenance costs. Some companies may have to delay start-up until July and may have difficulties even then, particularly with Regime 1 (AOS).

Arrow Lakes Reservoir

The very small differences in average reservoir elevations between all the regimes and their associated base cases, coupled with the fact that the range of elevations will not change, will result in slight, if any, impacts on water-based forestry activities, over and above those presently experienced.

Downstream Area

Present problems encountered by Westar in navigation, log storage and mill feeding operations may be exacerbated by the changes in outflows with all regimes. Incremental impacts may occur due to more frequent daily flow changes from the implementation of alternate regimes.

Recreation

Mica Reservoir

The relatively large decreases in reservoir levels during June through September under the different regimes compared to their associated base cases will cause access problems and an unattractive exposed drawdown area which will detract from the recreational appeal of the area. With several years with Regime 1 (medium load and ARO) and in the majority of years studied with Regime 1 (AOS), average June elevations are below the level at which protruding stumps create navigation hazards. The problem would not occur with Regime 2 (medium load).

Under the base cases, all boat launch ramps would be usable only from June through September. With the alternate regimes, none of the existing ramps except for Westar's barge points will be usable in May under average conditions, and several will not be usable during other recreation months, particularly June, in some years. With all alternate regimes and base cases, minimum elevations are generally always too low for use of the boat launch ramps, particularly at the private resorts in the southern half of the reservoir (at Esplanade Bay and Beavermouth Creek) and recreation sites at the northern end.

Sport fish populations may be affected by the alternate regimes, which may compound access and navigation impacts on recreational fishing.

Arrow Lakes Reservoir

The very slight differences in Arrow Lakes elevations between all four alternate regimes and their associated base cases are not expected to affect recreation. No measurable impacts are predicted on sport fish and wildlife, therefore recreational fishing and hunting will not be affected by the change in operating regime.

Downstream Area

With all regimes, the slight changes in median monthly outflows projected compared to the associated base case should not affect recreation facilities as they have been constructed to accommodate changes in flows. However, recreational boaters could experience navigation and access difficulties during prolonged periods of minimum or maximum flows under both alternates and base case.

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GLOSSARY

As with any statistical study, the terminology utilized can be confusing to the lay reader. In order to simplify and add clarity to the text, the following standard terminology has been adopted in this volume:

study year - means a year beginning on 1 September and ending on 31 August

monthly - means the average over a monthly period

monthly period - means the complete months of January, February, March, May, June, July, September, October, November, December, and the four semi-monthly periods comprising the first 15 days of April, the last 15 days of April, the first 15 days of August, and the last 16 days of August

median - means the median or 50th percentile of a 200 game statistical distribution for a specific monthly period of a specific study year

average - means the average over all study years of the medians for a specific monthly period

annual - means the average over all monthly periods of the average medians

high - means the highest median value for a specific month over the 20 year study period

low - means the lowest median value for a specific month over the 20 year study period

minimum - means the 0th percentile of a 200 game statistical distribution for a specific monthly period of a specific study year

average minimum - means the average over all study years of the minimum for a specific monthly period

annual minimum - means the average over all monthly periods of the minimums for a specific study year

annual average minimum	-	means the average over all monthly periods of the average minimums
maximum	-	means the 100th percentile of a 200 game statistical distribution for a specific monthly period of a specific study year
average maximum	-	means the average over all study years of the maximums for a specific monthly period
annual maximum	-	means the average over all monthly periods of the maximums for a specific study year
annual average maximum	-	means the average over all monthly periods of the average maximums

1.0 INTRODUCTION

The British Columbia Hydro and Power Authority (BCHPA) is presently negotiating a reservoir coordination agreement with Bonneville Power Administration (BPA) to utilize the storage of water in reservoirs controlling the Columbia River, beyond that covered under the existing Columbia River Treaty and the existing Non-Treaty Storage Agreement.

The intent of a new agreement for use of non-treaty storage is to optimize power generation over the whole length of the Columbia River within licence and power transmission restraints. Currently, 2.47×10^9 m^3 (2.0 million acre feet (MAF)) of Mica Reservoir non-treaty storage is being utilized under the present Non-Treaty Storage Agreement, which expires in 1993. BCHPA proposes to make an additional 3.71×10^9 m^3 (3.0 MAF) of non-treaty storage behind Mica Dam available for use under the proposed new agreement. This water can be used to generate additional hydroelectric energy at both Mica and Revelstoke Dam generation facilities as well as at U.S. facilities along the Columbia River.

Triton Environmental Consultants Ltd. (formerly Envirocon Pacific Ltd.) was contracted by BCHPA to assess the potential environmental impacts of changes in operation of the Mica and Arrow Lakes Reservoirs as a result of alternative reservoir operating regimes involving the use of non-treaty water storage.

The purpose of this report is to present the findings of an assessment of the potential environmental impacts of the alternate regimes, including effects on water quality, fish, wildlife, heritage resources, and water-based uses relating to settlements, forestry, agriculture and recreation. A summary of this report was prepared and is available from BCHPA under separate cover.

1.1 Study Scope

The report briefly describes the history of the Mica and Arrow Lakes Reservoir areas and provides environmental baseline and resource use information. An assessment is made of the potential impacts of four reservoir operating regimes which use differing energy loadings compared to an associated base case. These regimes are described in Section 1.3.

Increased use of the non-treaty storage under negotiation between BCHPA and BPA would affect water storage in Mica Reservoir, impounded by Mica Dam and, consequently, operation of the Arrow Lakes Reservoir, impounded by Hugh Keenleyside Dam. Therefore, only these reservoirs are considered in this study. As the Revelstoke Canyon power project is operated as a run-of-river plant, and no change in its operation is contemplated under the proposed Non-Treaty Storage Agreement, it is not included in this study. Also, as the Revelstoke Reservoir extends almost to the base of Mica Dam, the small reach of the Columbia River below Mica Dam has not been considered in detail. However, the river system downstream of Hugh Keenleyside Dam has been considered in detail. The proposed agreement would not affect operation of projects on the Kootenay River system.

The cumulative effects of the use of additional non-treaty storage on any other energy projects which may be developed on the Columbia River, such as the proposed Murphy Creek project, have not been addressed in this report but will be addressed in other individual project studies.

1.2 Study Methods

The methods used to assemble and analyze the environmental data are described in the following three categories:

1) methods used to obtain and document background data on existing environmental conditions;

2) methods used to manipulate the flow and elevation data provided by BCHPA into formats useful for the impact assessment; and

3) methods used in the assessment and ranking of possible environmental impacts resulting from changes to the Non-Treaty Storage Agreement.

1.2.1 Documentation of Environmental and Resource Use Profile

In determining existing environmental conditions, the study team relied on existing data, especially on existing data in the B.C. Hydro library, personal communication with government officials and with industry, on the results of two field trips to examine key fish and wildlife habitats along each reservoir, and on experience gained on similar projects throughout British Columbia. As no discussions have been held with public groups regarding resource use, documentation of the environmental profile and the assessment of impacts must be considered preliminary at this time. The report does, however, provide a framework for useful discussion of this information with government, public and industry representatives.

A brief history of issues is provided where required to understand existing environmental conditions or resource use conflicts. As much of the study area has been affected by previously constructed hydroelectric and flood control structures, the historical development of the Columbia River system is summarized. Where relevant, pre-impoundment flow and lake elevation data are presented along with water release and reservoir elevation data after impoundment.

1.2.2 Manipulation of Flow and Elevation Data

Monthly flow and elevation data for the different regimes were provided by BCHPA, from studies conducted by BPA, using their Systems Analysis Model (SAM). The regimes were the result of modelling the effect of different power production and sales policies on the operation of the Mica and Arrow Lakes Reservoirs utilizing additional non-treaty storage behind Mica Dam (discussed in more detail in Section 1.3).

The SAM model produced flow and elevation data for 200 separate sets of hydrological conditions for each year over a 20 year period, under alternate energy production and marketing scenarios. Calculated results are presented as a statistical distribution of possible monthly flows and elevations at each of the generating facilities based on the 200 separate data sets. Data for each reservoir were transmitted as 200 possible monthly flows and elevations, and these distributions were further analyzed by Triton.

The large volume of data was most readily assimilated in graphical form. To this end, elevation and flow data for each energy load scenario for each reservoir were plotted as cumulative distribution curves. The use of these curves allow the data for each scenario to be presented together (a typical graph is shown in Figure 1.1). By comparing the graphs for alternate operating regimes, differences in elevations and outflows at each reservoir can be readily demonstrated.

The minimum, median and maximum curves and the curves for the 10% and 90% values for the distributions were plotted. The minimum and maximum curves represent the lowest and highest of the simulated conditions, respectively, that are expected to occur under each scenario. These extreme values are not likely to happen often and although they are useful indications of the possible range of operating flows or elevation changes, they do not provide information on changes in average (expected conditions). The median curve can be thought of as representing average conditions, to the extent that the data are uniformly distributed.

When using these curves it must be remembered that the data do not represent an annual hydrograph. The curves were compiled by ranking the 200 monthly data generated for each year of each scenario and determining the cumulative distribution of all the data. Only the minimum, maximum and median points, as defined above, of the distribution were plotted.

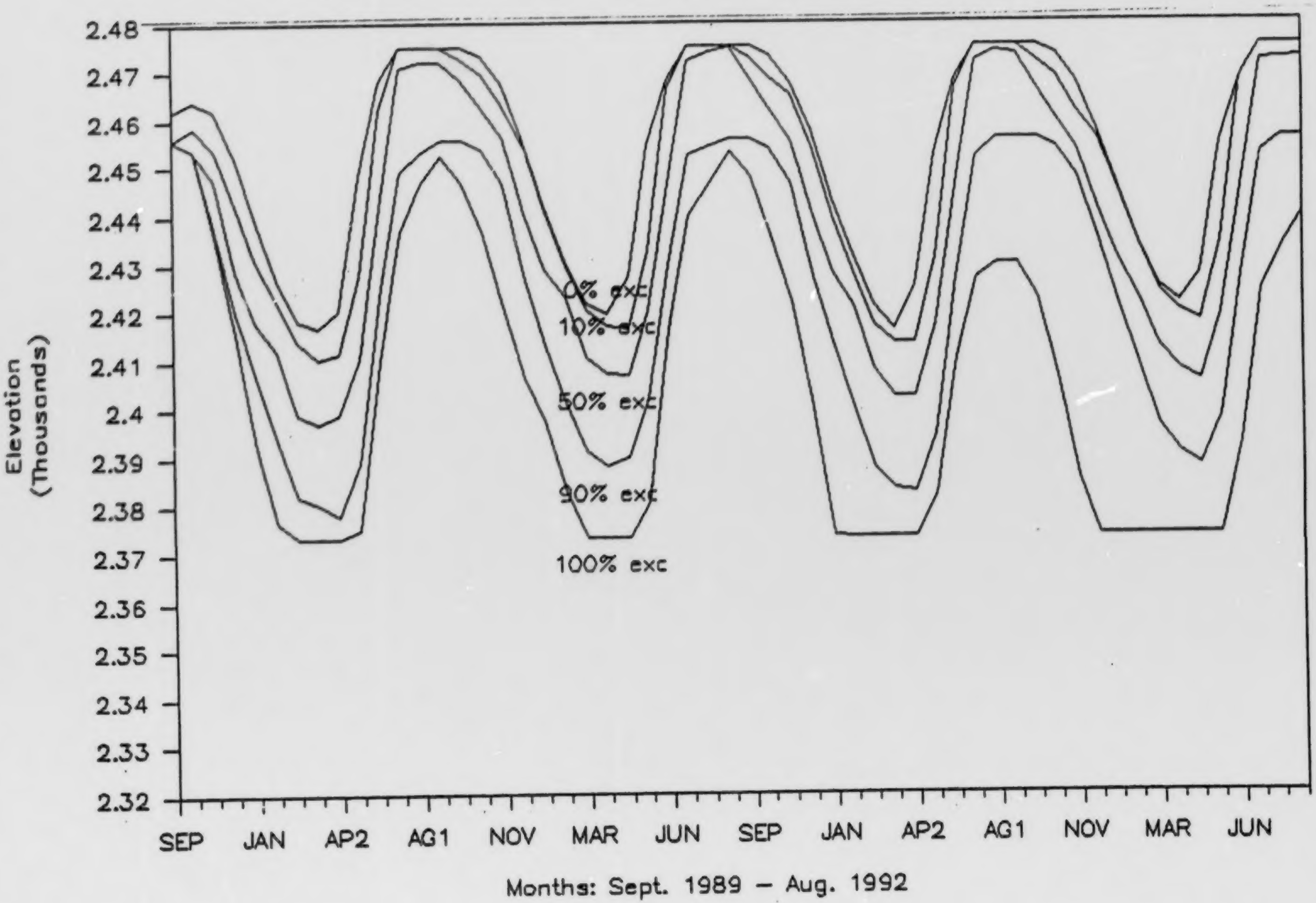
As mentioned above, the median statistic represents average conditions. Therefore, although changes in extreme values are noted, much of the impact assessment focuses on changes in median conditions.

1.2.3 Impact Assessment

The environmental impact assessment was conducted in three steps:

1) assessment of changes in the physical environment;

Figure 1.1 Typical Summary Hydrograph - Elevations at Mica Reservoir, Base Case (Medium Load): September 1989 - August 1992



2) assessment of changes in the biological environment with aquatic and terrestrial species and habitats treated separately at first and then, as required because of food chain or other interactions, together; and

3) assessment of changes in resource uses.

The results of one step were used in the next, to allow the determination of the overall effect of changes in downstream flow releases and reservoir operating levels.

1.3 Description of Alternate Operating Regimes

As previously noted, physical data on alternate reservoir operating regimes were supplied by BCHPA in conjunction with BPA, consisting of statistical distributions of monthly reservoir elevations and outflows from Mica and Arrow Lakes Reservoirs. Semi-monthly data were supplied for April and August as the reservoirs reach minimum and maximum levels during these months, respectively, and data on any of the potential changes in the timing of the achievement of these levels were required. These data were subsequently put into graph and summary table format by Triton for use in the comparative analyses. The statistical data were generated by BPA's System Analysis Model (SAM), which simulated operation of the U.S. Pacific Northwest and B.C. power systems on a monthly basis. The SAM model incorporates statistical methods to simulate variations due to uncertainties in regional loads, thermal plant performance and streamflows. For each study case, a 20-year (1989-2008) simulation was run a total of 200 times, each time with a random selection of each variable. The result was 200 data points for each month of the study (240 months) for each parameter of interest (eg. Mica and Arrow elevations and outflows). These data are on file at BCHPA.

The data represent a statistical time series of possible outcomes for each regime in response to changes in both operating conditions and variations in reservoir inflows over the twenty year period. These statistical distributions cover the range of expected variation in each parameter for the assumed operating regime. The impact assessment is based mainly on projected median reservoir levels and outflows averaged over the 20-year study period. However, extreme minima and maxima have also been considered.

The SAM model attempts to simulate the actual operation of the power systems based on simplified decision criteria. The SAM model is intended to provide a reasonable indication of the range of operations expected for the non-treaty storage so that the SAM results can be used to assess the sensitivity of environmental resource impacts to different operating regimes. However, SAM does not predict the actual operation of the non-treaty storage, but rather gives an indication of the probability that the operation will be within certain limits for a particular operating regime.

The SAM studies examined two generic operating regimes: Regime 1 based on using non-treaty storage for opportunity sales, and Regime 2 based on using non-treaty storage as a firm resource. The operation of the non-treaty storage will not necessarily follow either of these generic regimes for the full term of the proposed agreement. Actual operation is likely to be a combination of or variation on these basic regimes at different times during the agreement.

The comparisons made for the assessment are summarized in Table 1.1.

1.3.1 No Action - Base Case Regime

The Base Case regime assumes that no new agreement is negotiated and that BCHPA continues to operate the reservoirs under the terms of the Columbia River Treaty and the current Non-Treaty Storage Agreement, which expires in 1993. The latter agreement calls for the use of 2.47 x 10^9 m^3 (2 MAF) of storage behind Mica Dam, divided equally between BCHPA and BPA. Base Case energy production is based on medium or average forecast loads.

1.3.2 Non-Treaty Storage Agreement Alternative Operating Regimes

Under the operating regimes described below, the use of non-treaty storage is assumed to be expanded to 6.18 x 10^9 m^3 (5 MAF) and the period of operation is assumed to extend to 2008.

TABLE 1.1

Comparisons Made in the Impact Assessment

	No Action		Proposal	Energy Load Scenario
1.	Base Case - 2.47×10^9 m^3 (2.0 MAF) of non-Treaty storage used to 1993.	vs.	Regime 1 - 6.18×10^9 m^3 (5.0 MAF) of non-Treaty storage used to 2008.	Medium Loads - opportunity sales of energy
2.	Base Case (ARO) - 2.47×10^9 m^3 (2.0 MAF) of non-Treaty storage used to 1993.	vs.	Regime 1 (ARO) - 6.18×10^9 m^3 (5.0 MAF) of non-Treaty storage used to 2008.	Alternate Resource Order - change in priority of energy production from facilities
3.	Base Case (AOS) - 2.47×10^9 m^3 (2.0 MAF) of non-Treaty storage used to 1993.	vs.	Regime 1 (AOS) - 6.18×10^9 m^3 (5.0 MAF) of non-Treaty storage used to 2008.	Alternate Operating Scenario for opportunity sales - more active use of non-Treaty storage
4.	Base Case - 2.47×10^9 m^3 (2.0 MAF) of non-Treaty storage used to 1993.	vs.	Regime 2 - 6.18×10^9 m^3 (5.0 MAF) of non-Treaty storage used to 2008.	Medium Loads - use non-Treaty storage as a firm resource

Cross reference to comparison in BPA's Environmental Assessment:

1. Base Case (ARO) vs. Regime 1 (ARO) is BPA's base case comparison under the "Opportunity Storage" proposal.

2. Base Case (AOS) vs. Regime 1 (AOS) is designated by BPA as the sensitivity comparison under the "Alternative Dispatch Criteria".

3. Base Case vs. Regime 2 is BPA's base case comparison under the "Firm Resource" proposal.

Regime 1

This regime assumes that the non-treaty storage would be used for opportunity sales by BPA and BCHPA. The intent is to store water in non-treaty storage during high runoff and poor market conditions, and release it at another time for generation to serve higher valued markets. The storage is not reserved to serve firm load, but serving firm load is not precluded. As with the Base Case, energy production is based on medium or average forecast loads.

Alternate Resource Order (ARO)

Current operating strategies for energy production assume that energy will be produced at different plants based on operation priorities. Changes to the priority given energy production at different plants could also affect the reservoir operations. Therefore, the environmental sensitivity of these changes is tested by making a comparison between current operating conditions and an alternate policy. These are designated the Alternate Resource Order (ARO) Base and Regime 1 cases, respectively.

BPA have indicated that the operation priorities under the ARO case are the more likely priorities that would be adopted for operation of U.S. projects.

Alternate Operating Scenario (AOS)

The strategies adopted by BCHPA and BPA for utilizing non-treaty storage to make opportunity sales may result in more active use of non-treaty storage. Therefore, a comparison is made in this report of the environmental consequences of more active and frequent use of non-Treaty storage under the Base Case, No-Action Scenario and Regime 1 to assess the sensitivity of environmental resources.

Regime 2

Under this operating regime, the use of non-treaty storage and term of agreement are the same as in Regime 1. However, the storage is assumed to be used as a firm resource by both BCHPA and BPA for the entire 20 year period to 2008. It is expected that the use of expanded non-treaty storage space would start by using Regime 1 and could potentially change to Regime 2 when additional resources are needed to meet firm load. By studying both alternatives, potential environmental effects can be bounded without specifying the exact time when the change may occur. The decision to use non-treaty storage as a firm resource may be made by either BPA or BCHPA independently of each other.

2.0 BACKGROUND

2.1 History of Region Prior to the Columbia River Treaty

People have lived in and used the region encompassing the Arrow Lakes and the Upper Columbia River over a long time period. Before European contact the region was seasonally inhabited by native Indians who were part of the Lakes Group of the Interior Salish Tribe, which was a semi-nomadic river-oriented group. In the early 1800's the native population was roughly 300 to 500, and they used the Columbia River as a transportation route between their summer camps around the Lakes and main villages in the vicinity of Colville, Washington. Indians from the Okanagan and Shuswap bands from the west and from the Kootenay band, a different linguistic group originating from the Blackfoot Indians of southern Alberta, also camped around the lakes in summer. Heavy winter snows, particularly in the northern part of the region, discouraged year-round occupancy.

The seasonal visits of the Indians had ceased by the late 1800's as all of their customary campsites had been occupied by white settlers. By 1954 the resident Indian population was one of the most sparse in British Columbia.

In the early 1800's European explorers visited the area. David Thompson reached the Rocky Mountain Trench, approaching the Columbia River from the Howse Pass and Blaeberry Creek in 1807. He explored the East Kootenays for three years and overwintered at Boat Encampment in the Big Bend area, journeying from there to the mouth of the Columbia River in 1811. Afterwards, the Columbia River served as the main fur trade route between eastern Canada and southern B.C., Washington and Oregon until the U.S.-Canada boundary was established in 1846.

Gold was discovered in the Big Bend area in 1860 and by 1865 some 10,000 placer miners had worked in the area. In the period 1865 to 1871, surveyors searched the region for a suitable east-west route for a transcontinental railway. The Canadian Pacific Railway route through the Rogers Pass was subsequently located and the railway was built in the late 1880's. A permanent community was established at Farwell, now Revelstoke, and in the years following, numerous communities based primarily on sawmilling, farming and mining came into being along the railway route.

Initial logging between 1865 and 1896 involved the cutting of cordwood for steamboats plying the Columbia River and the Arrow Lakes from Colville in Washington to Revelstoke and the Big Bend. By 1890, small sawmills and shinglemills were being built in such towns as Golden, Nakusp and Castlegar.

Both mining and sawmill activity rose and fell with demand, and supplies of locally grown produce were seldom reliable. With the exception of Revelstoke, on the Canadian Pacific Railway mainline, the only surviving communities are those that have been continuously supported by forest industries. The small communities evolved a pleasant rural lifestyle to which hunting and fishing were important. A major loss occurred in the 1940's when construction of the Grand Coulee Dam on the Columbia river in the U.S. prevented salmon from migrating to the upper Columbia River.

In 1952 Celgar Limited acquired three sawmills controlling over 60% of the timber harvested in the entire Columbia drainage in Canada and in 1955 the B.C. government awarded Tree Farm Licence (TFL) 23 to Celgar to support a pulpmill complex at Castlegar. The mill began operating in 1961. TFL 23 is now owned by Westar Timber Corporation, which has a large sawmill at Castlegar. In 1953 the Rogers Pass route was selected for the Trans Canada Highway. Revelstoke and Golden began to develop as service centers for tourists as well as forest industry centers.

Valemount, at the northern end of the present Canoe Reach of Mica Reservoir, developed in much the same way as Golden at the southern end. Some farming occurred in the late 1800's, but no significant growth took place until the Canadian National Railway was built through the Yellowhead Pass and the first sawmill established in 1912. Construction of the Trans Mountain oil pipeline in 1950 to 1952 boosted the local economy and the first major sawmill was developed in 1957. Completion of the Yellowhead Highway in 1964 established Valemount as a tourist service center (E.L.U.C. 1974b). The forest industry is still the dominant industry supporting the economy of the region.

2.2 The Columbia River Treaty and Resulting Developments

The Columbia system in Canada is controlled by five large dams (one, the Libby Dam, is located in the United States), and a number of smaller, run-of-river dams (Figure 2.1). The two largest reservoirs in the system are Mica Reservoir, impounded by Mica Dam (Figure 2.2), and Arrow Lakes Reservoir, behind Hugh Keenleyside Dam (Figures 2.3 and 2.4). The Columbia River below Hugh Keenleyside Dam to the U.S. border, a stretch of approximately 58 km (36 mi), is shown in Figure 2.5.

The Columbia River Treaty between Canada and the United States was signed in 1961 and ratified in 1964. The flood of 1948, which caused extensive damage in both Canada and downstream in the U.S., is cited as one of the principal reasons for establishing the Treaty. BCHPA was designated as the Canadian Entity to administer the Treaty.

Under the Treaty, Canada was required to build three storage dams for the purpose of regulating downstream flows to the U.S. A total of 19.12×10^9 m^3 (15.5 Million Acre Feet [MAF]) of live water storage was required to be provided in Canada. The three reservoirs created in Canada and the amount of storage required under terms of the Treaty are:

1) Mica Reservoir (8.64×10^9 m^3 [7 MAF])
2) Arrow Lakes Reservoir (8.76×10^9 m^3 [7.1 MAF]); and
3) Duncan Lake Reservoir (1.73×10^9 m^3 [1.4 MAF]).

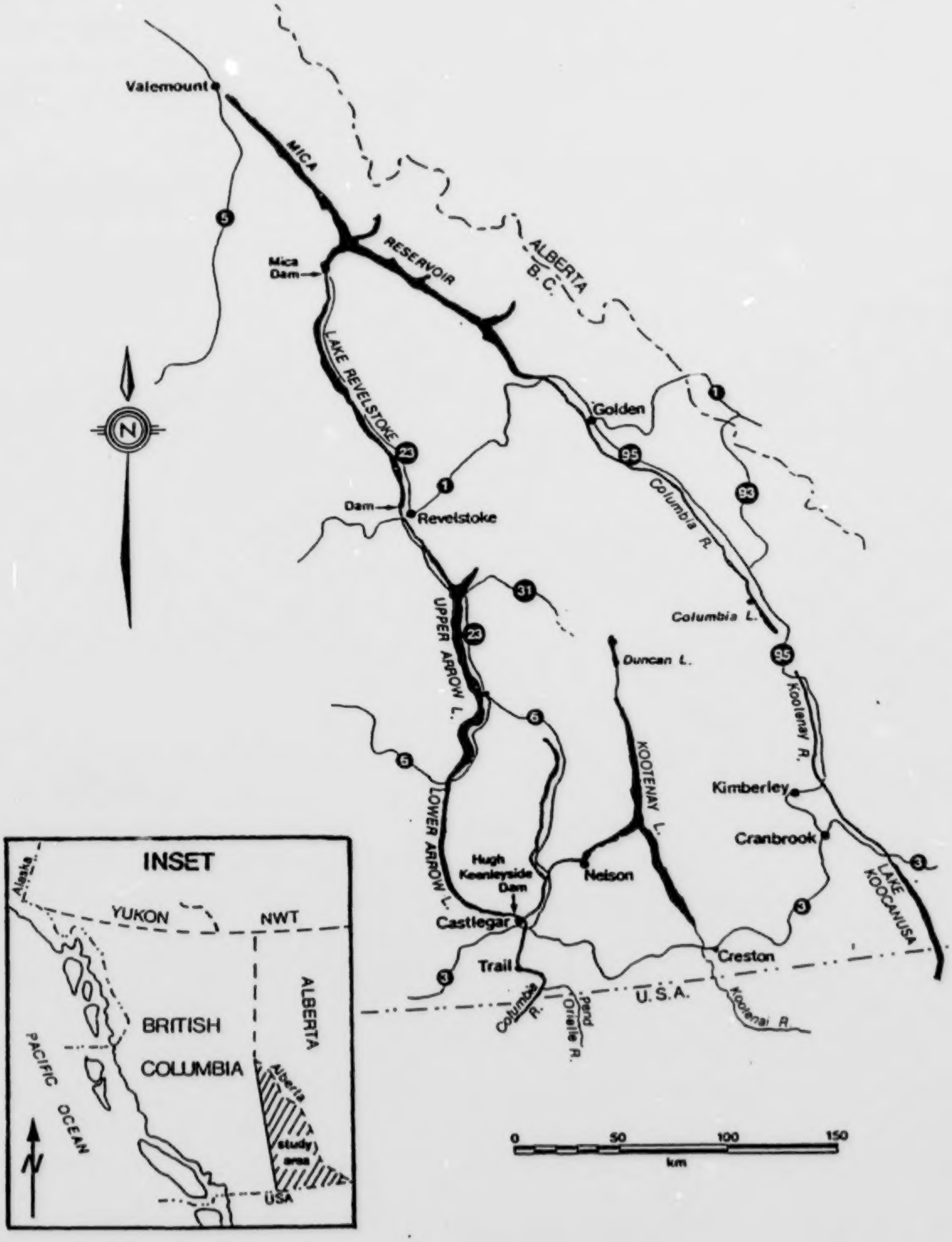
Duncan Lake Reservoir will not be affected by a renegotiation of the Non-Treaty Storage Agreement and, thus, is not described below.

In addition to the 19.12×10^9 m^3 (15.5 MAF) of storage required by the Treaty, B.C. Hydro also constructed an additional 6.18×10^9 m^3 (5 MAF) of storage at Mica Reservoir. As noted, 2.47×10^9 m^3 (2 MAF) of the Mica Reservoir non-treaty storage is currently being shared equally under a Non-Treaty Storage Agreement between BPA and BCHPA.

2.2.1 Mica Reservoir

Construction of Mica Dam began in 1963 and was completed in 1973. The dam is 244 m (800 ft) high and has a crest length of 793 m (2602 ft). The present generating capacity of the powerhouse is 1736 megawatts (MW) from four generators and there is potential to install two more generators for an ultimate capacity of 2604 MW. Total live storage of the

Figure 2.1 **Columbia River System**


Valemount
MICA
RESERVOIR
Mica Dam
ALBERTA
B.C.
5
LAKE REVELSTOKE
N
23
1
Dam
Revelstoke
Golden
95
Columbia R.
93
1
UPPER ARROW L.
31
23
Columbia L.
Duncan L.
95
Kootenay R.
6
6
KOOTENAY L.
LOWER ARROW L.
Kimberley
Cranbrook
Hugh Keenleyside Dam
Nelson
LAKE KOOCANUSA
3
3
Castlegar
Trail
Creston
3
U.S.A.
Columbia R.
Pend Oreille R.
Kootenai R.
0
50
100
150
km
INSET
Alaska
YUKON
NWT
BRITISH
COLUMBIA
ALBERTA
PACIFIC OCEAN
Alberta
study area
USA
N

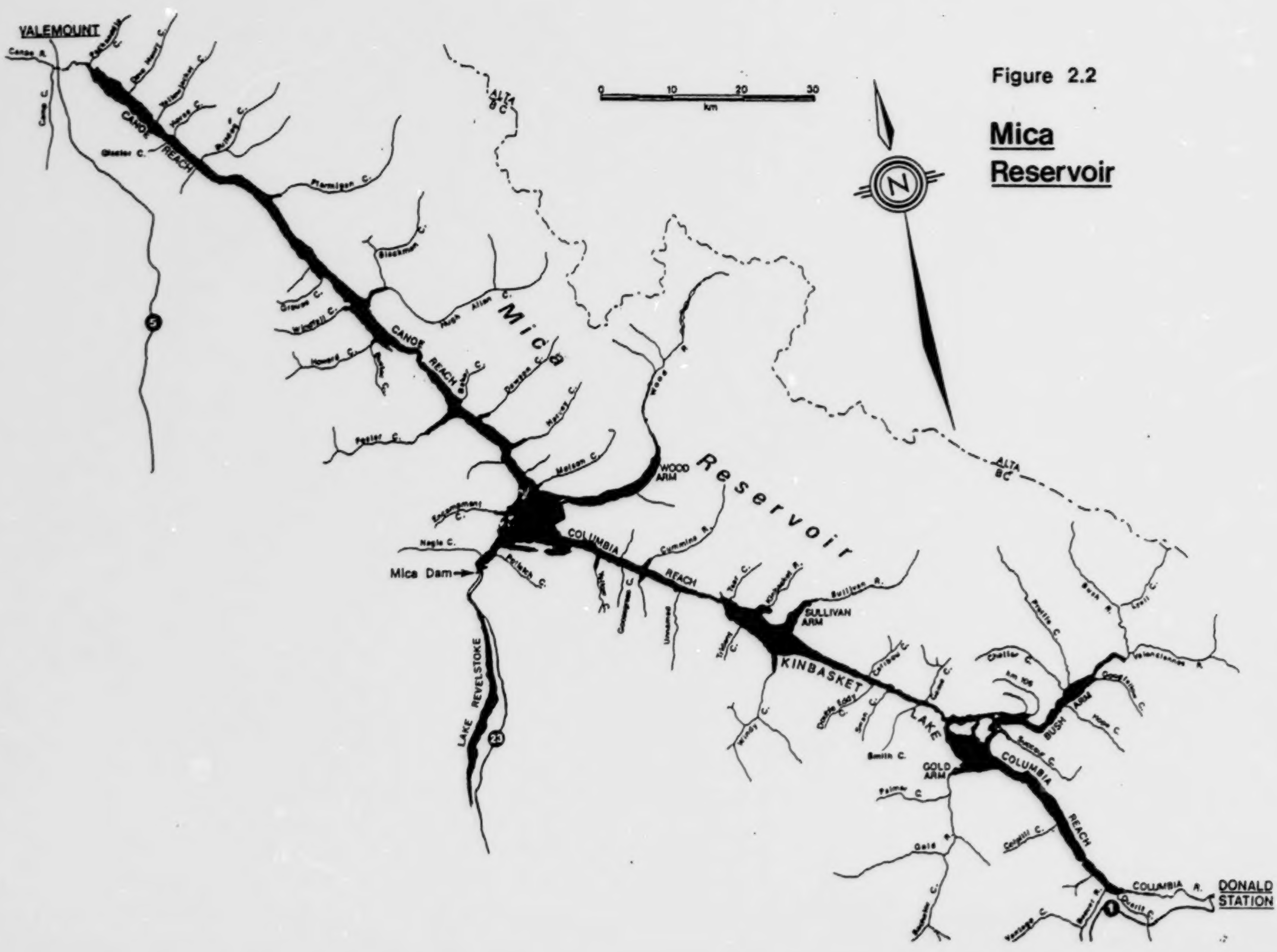

VALEMOUNT
Canoe R.
Camp C.
Packsaddle C.
Dave Henry C.
Yellowjacket C.
Horse C.
Running C.
Glacier C.
CANOE REACH
Ptarmigan C.
Blackman C.
Grouse C.
Windfall C.
Howard C.
Bulldog C.
Hugh Allan C.
CANOE REACH
Bates C.
Dawson C.
Harvey C.
Foster C.
Molson C.
5
Mica
Wood R.
WOOD ARM
Reservoir
Encampment C.
Nagle C.
Mica Dam
Potlatch C.
COLUMBIA
REACH
Yellow C.
Goosegrass C.
Unnamed
Cummins R.
Tsar C.
Kinbasket R.
Trident C.
Sullivan R.
SULLIVAN ARM
KINBASKET
LAKE
Windy C.
Double Eddy C.
Swan C.
Caribou C.
Smith C.
GOLD ARM
Palmer C.
Gold R.
Bachelor C.
Chatter C.
km 106
Prattle C.
Bush R.
Lyell C.
Valenciennes R.
Conflict C.
BUSH ARM
Hope C.
Succour C.
COLUMBIA
REACH
Cargill C.
Vantage C.
Bluewater R.
Quartz C.
1
23
COLUMBIA R.
DONALD STATION
LAKE REVELSTOKE
ALTA BC
ALTA BC
0
10
20
30
km
N

Figure 2.2

Mica Reservoir

Figure 2.3 Upper Arrow Lake

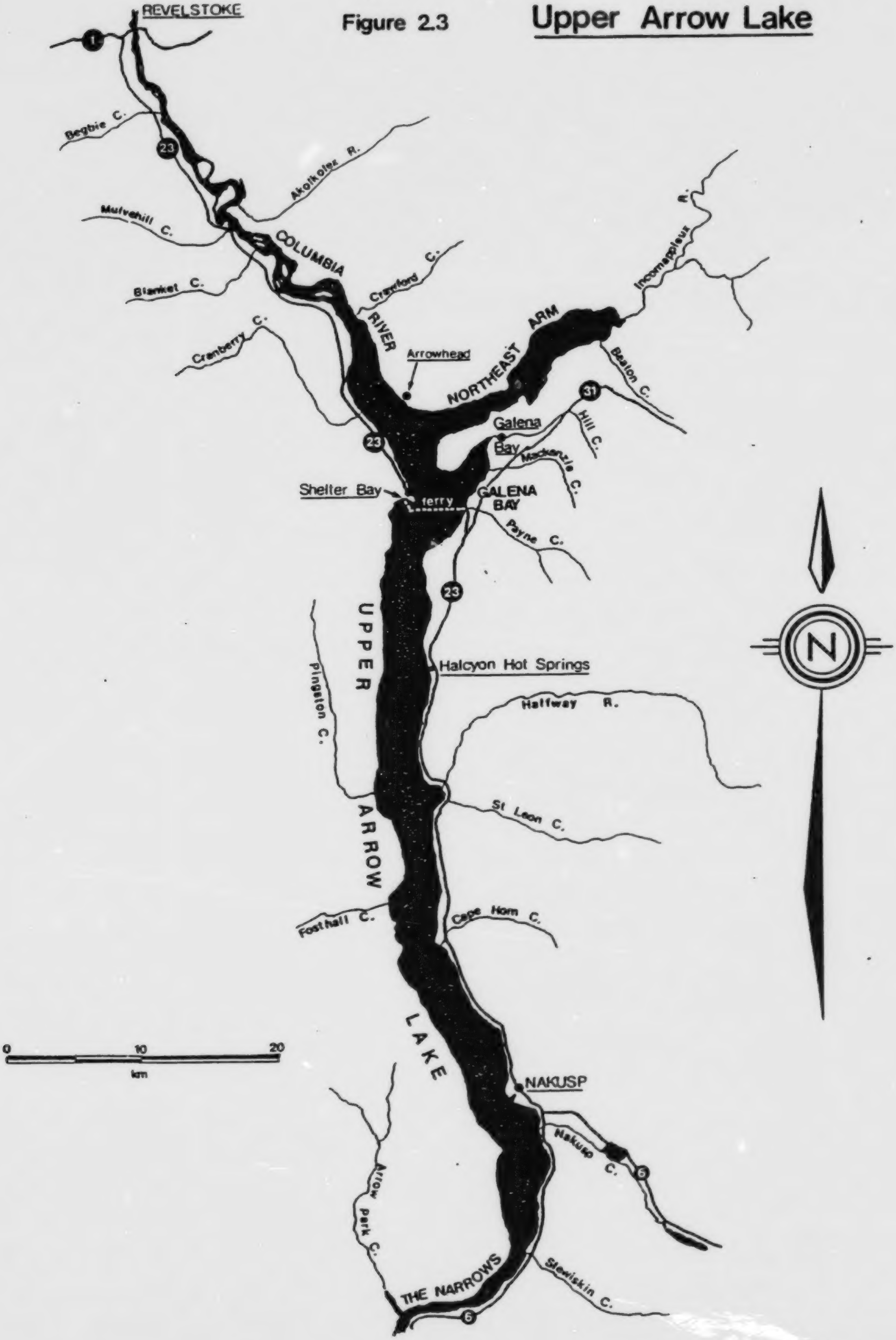
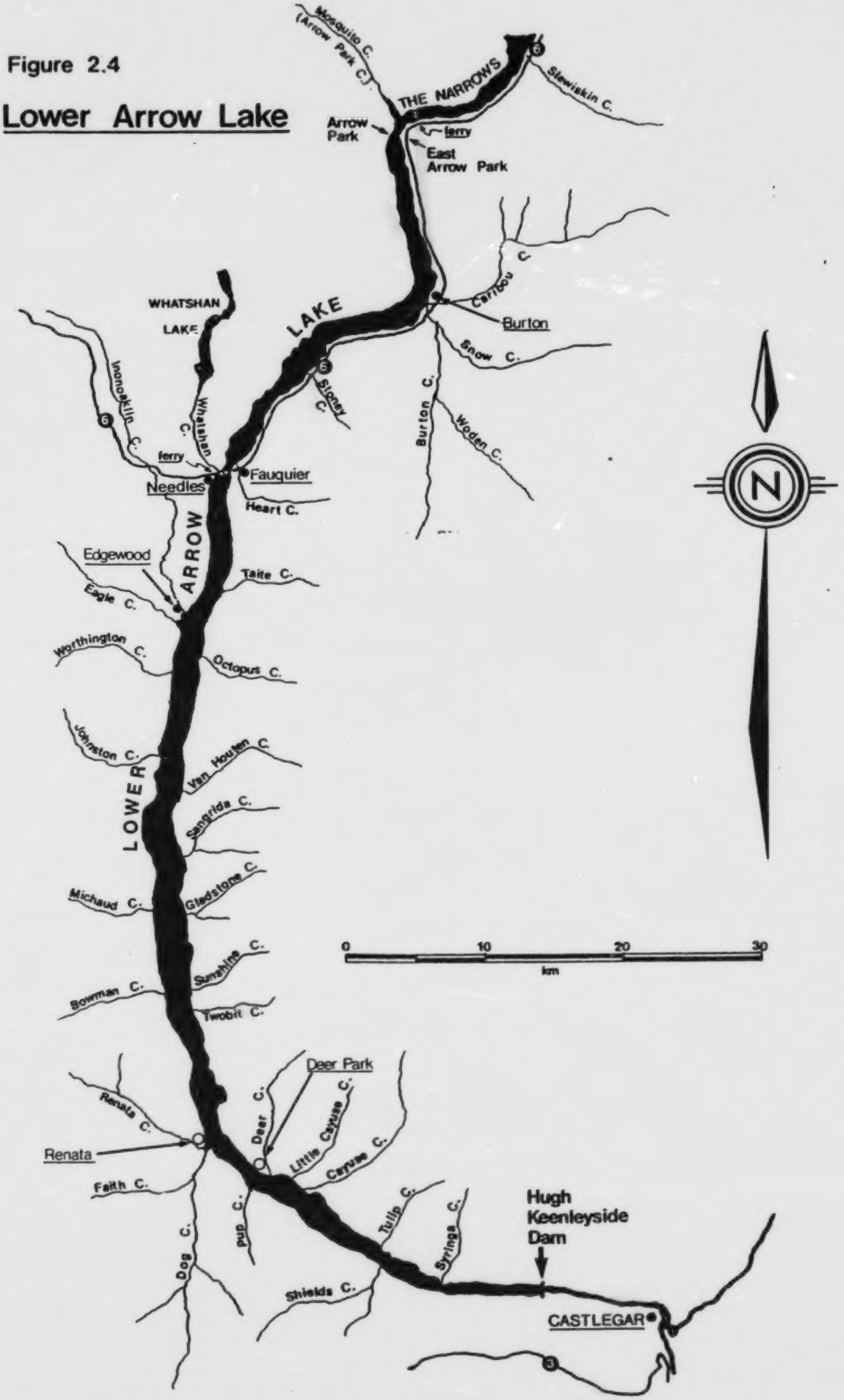

REVELSTOKE
1
23
Begbie C.
Akolkolex R.
Mulvehill C.
COLUMBIA
Blanket C.
RIVER
Crawford C.
Cranberry C.
Arrowhead
NORTHEAST ARM
Incomappleux R.
Beaton C.
31
Hill C.
Galena Bay
Mackenzie C.
Shelter Bay
ferry
GALENA BAY
Payne C.
UPPER ARROW LAKE
Halcyon Hot Springs
Pingston C.
Halfway R.
St Leon C.
Fosthall C.
Cape Horn C.
0
10
20
km
NAKUSP
Nakusp C.
6
Arrow Park C.
THE NARROWS
Slewiskin C.
N

Figure 2.4

Lower Arrow Lake



Mosquito C.
(Arrow Park C.)
THE NARROWS
6
Slewiskin C.
Arrow Park
ferry
East Arrow Park
Caribou C.
Burton
Snow C.
Burton C.
Woden C.
LAKE
6
Stoney C.
WHATSHAN LAKE
Inonoaklin C.
6
Whatshan C.
ferry
Needles
Fauquier
Heart C.
ARROW
Edgewood
Eagle C.
Taite C.
Worthington C.
Octopus C.
Johnston C.
Van Houten C.
LOWER
Sangrida C.
Gladstone C.
Michaud C.
Sunshine C.
Bowman C.
Twobit C.
Deer Park
Deer C.
Little Cayuse C.
Cayuse C.
Renata C.
Renata
Faith C.
Pup C.
Dog C.
Tulip C.
Syringa C.
Shields C.
Hugh Keenleyside Dam
CASTLEGAR
3
N
0
10
20
30
km

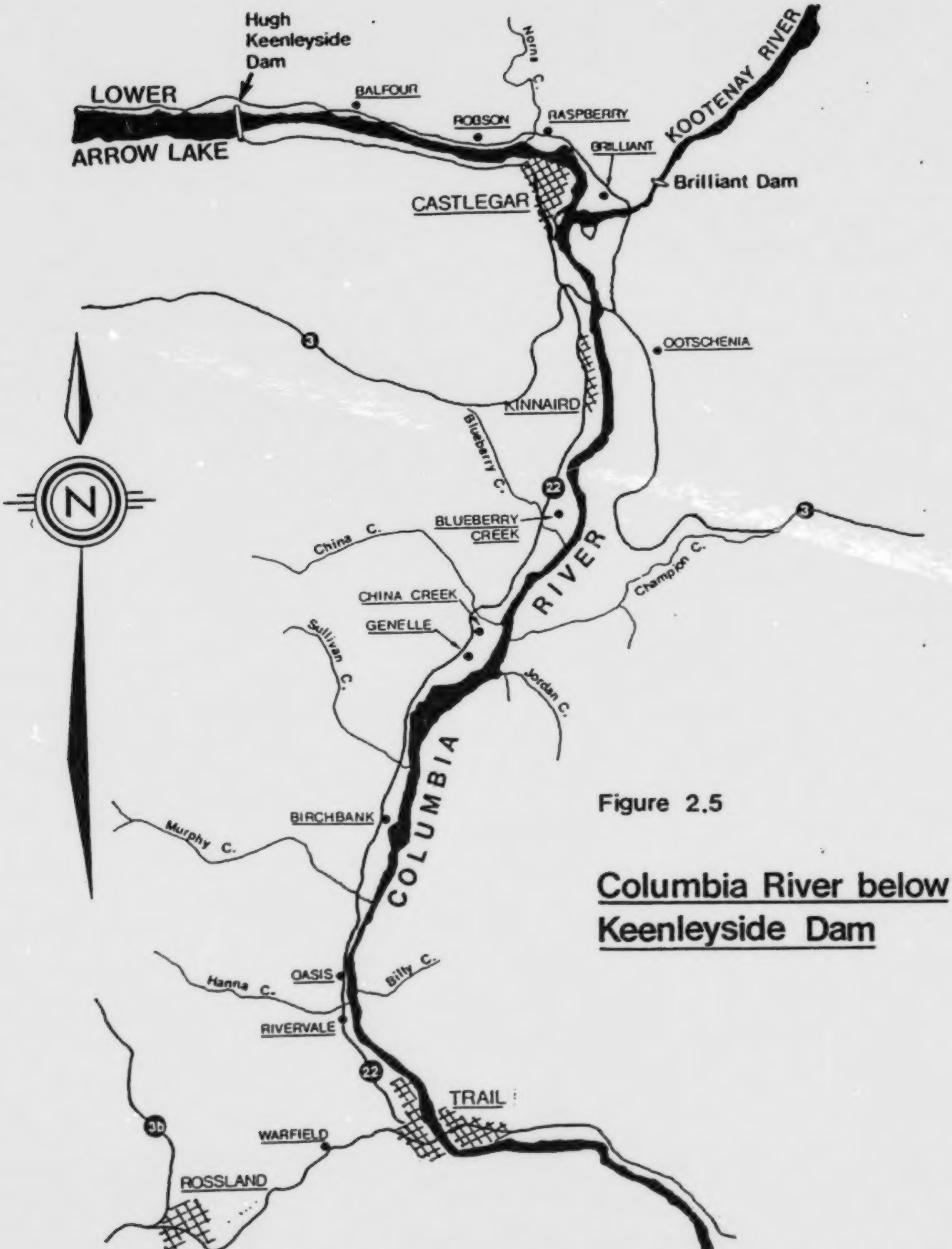

Hugh
Keenleyside
Dam
LOWER
ARROW LAKE
BALFOUR
ROBSON
Norns C.
RASPBERRY
BRILLIANT
KOOTENAY RIVER
Brilliant Dam
CASTLEGAR
OOTSCHENIA
3
KINNAIRD
Blueberry C.
22
BLUEBERRY
CREEK
3
China C.
Champion C.
CHINA CREEK
GENELLE
RIVER
Sullivan C.
Jordan C.
COLUMBIA
BIRCHBANK
Murphy C.
OASIS
Billy C.
Hanna C.
RIVERVALE
22
TRAIL
3b
WARFIELD
ROSSLAND
0 1 2 3 4 5
km
B.C.
U.S.A.
N

Figure 2.5

Columbia River below Keenleyside Dam

Mica Reservoir is 14.80 x 10^9 m^3 (12 MAF). As previously noted, as a term of the Columbia Treaty, 8.64 x 10^9 m^3 (7 MAF) was required to be stored in Mica Reservoir, leaving an additional 6.18 x 10^9 m^3 (5 MAF) of live storage. The reservoir is licensed to be operated between a minimum elevation of 707 m (2320 ft) and a maximum elevation of 754 m (2475 ft) (an operating range of 47 m (155 ft)). Currently, it is operated between approximately 735 m (2410 ft) and full pool. The reservoir usually reaches its lowest point in April and fills during May to August. The rate of filling varies with the rate of runoff. During those years when inflow is sufficient to fill the reservoir, the full pool level is usually attained in July or August (Figure 2.6).

The vast majority of land bordering the reservoir is Crown land, although there are a few small isolated privately-held lots. BCHPA owns land around the Mica Dam and has some property at the north end of the reservoir near Valemount. Large areas of Crown land near the reservoir are held under various forest tenures, discussed in more detail in Section 3.4.1 of the report.

2.2.2 Arrow Lakes Reservoir

The Arrow Lakes Reservoir is comprised of two lakes; Upper Arrow and Lower Arrow Lakes, and a small section of river south of Nakusp known as the Narrows. As a term of the Columbia River Treaty the Arrow Lakes Reservoir is required to store 8.76 x 10^9 m^3 of water (7.1 MAF), which is the total amount of available live storage. The Hugh Keenleyside Dam consists of a 370 m (1214 ft) long concrete discharge works, a 90 m (295 ft) navigation lock, and a 500 m (1640 ft) long earth fill dam. The navigation lock allows log transport to the Westar Timber Corporation sawmill at Castlegar and provides access for recreation boat traffic. Construction began in 1965 and the dam was completed in 1968. There are no power generation facilities at present, although the potential for low-head generation is currently being explored.

The water licence for Arrow Lakes Reservoir permits the water level to range between a minimum elevation of 420 m (1378 ft) and a normal maximum elevation of 440 m (1444 ft), an operating range of 20 m (66 ft). The reservoir reaches its lowest point in late March or early April and usually starts to fill in mid-May, reaching its highest level during the latter half of July (Figure 2.7).

Figure 2.6 Summary Hydrograph of Elevations at Mica Reservoir, Base Case (Medium Load): September 1989 - August 1992

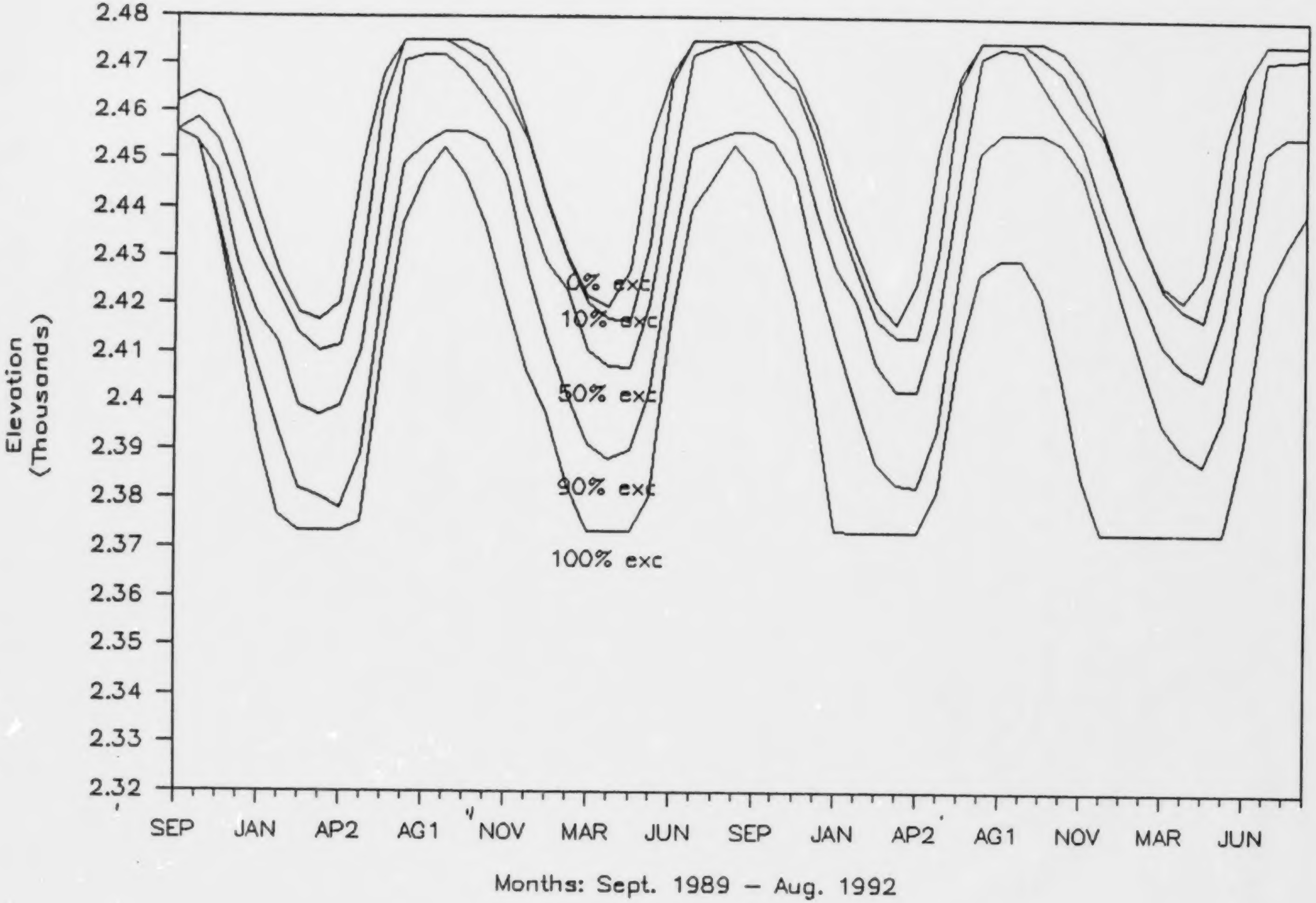
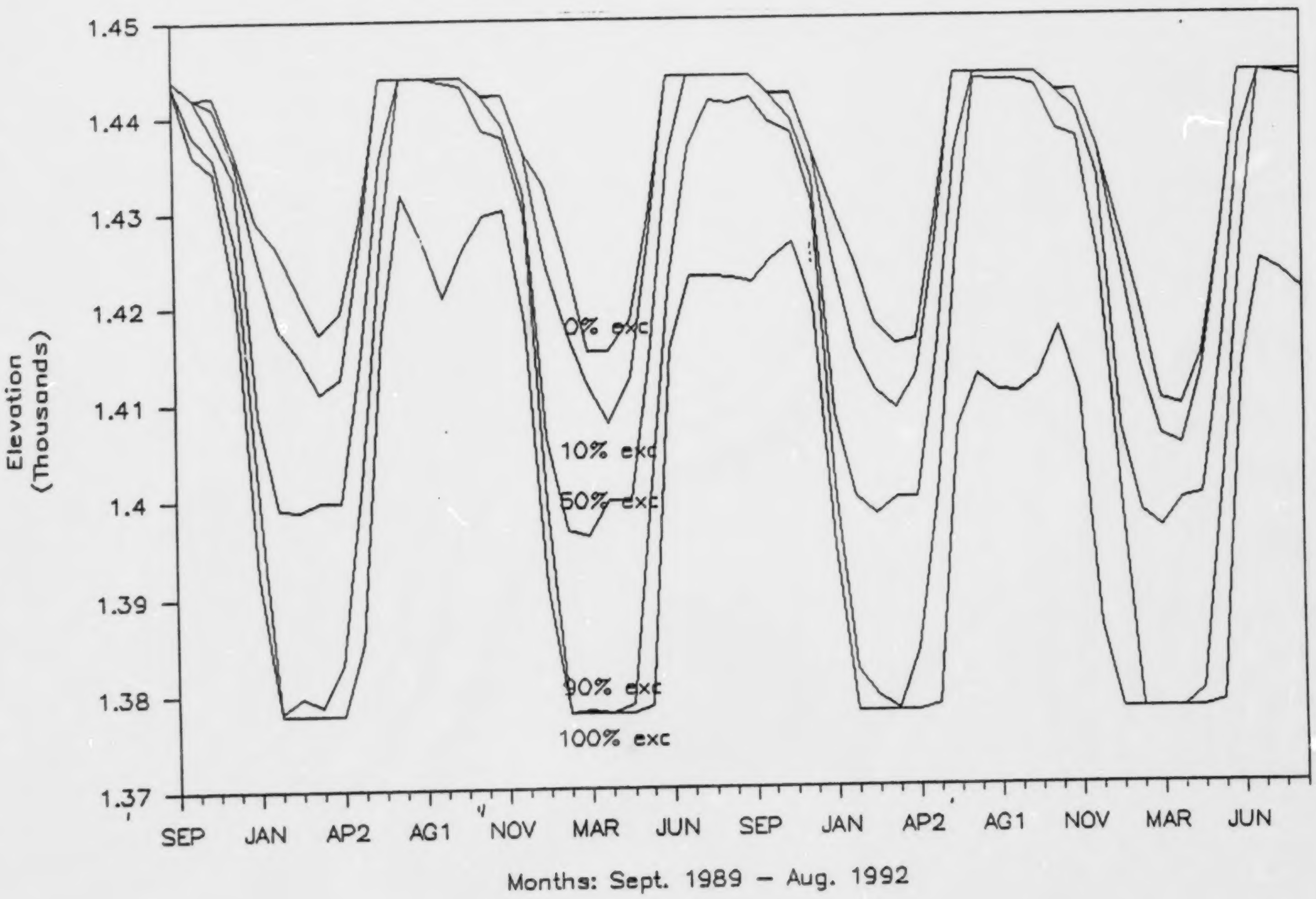


Figure 2.7 Summary Hydrograph of Elevations at Arrow Lakes Reservoir, Base Case (Medium Load): September 1989 - August 1992



The rate at which the reservoir empties is controlled largely by demand from the U.S. under the terms of the Columbia River Treaty. As the reservoir is the furthest downstream in Canada and as release of water from it can be used to postpone release of water from Canadian reservoirs with power generation facilities, the Arrow Lakes Reservoir is used to meet any early demand for water. Drawdown often begins in early August.

At the time of development, approximately 67% of the land flooded by the reservoir was privately owned. A major program of land acquisition was undertaken by BCHPA. The land acquired included all the small communities along the Columbia River between Revelstoke and Shelter Bay; and the communities of Arrowhead, Beaton, West Arrow Park, Demars, Burton, Fauquier, Edgewood, Needles and Renata on the main lakes. Deer Park and Broadwater were partially acquired (Sigma Resource Consultants 1975). Several of the communities were rebuilt in new locations. Three community graveyards were capped with concrete prior to inundation. After completion and flooding of the reservoir, much of the land bordering it was either returned to private ownership or transferred to the Crown. However, BCHPA still retains a number of land parcels.

3.0 DESCRIPTION OF REGION

3.1 Physical Environment

The Columbia River in Canada flows north along the Rocky Mountain Trench of southwestern British Columbia for approximately 314 km (195 miles) to Big Bend where it makes a 180 degree turn around the northern end of the Selkirk Mountains. The river then flows south through the Arrow Lakes and crosses the international border just south of Trail, B.C. The Columbia River flows a total of 739 km (459 miles) and has a drainage area of 102,435 square km (39,550 sq. mi) in Canada (Holland 1976).

3.1.1 Geography

Columbia Lake, the source of the Columbia River, is situated at an elevation of 812 m (2664 ft) above sea level (Figure 2.1). The Columbia River basin in the vicinity of Mica Reservoir lies in the Rocky Mountain Trench, which is a continuous, sinuous valley extending northwest from the U.S. border almost to the Liard River in the north. The area is characterized by steep mountain slopes, which rise from the floor of the Trench to El. 2743 m (9000 ft). The Rocky Mountains are on the eastern side of the Mica Reservoir and the Columbia Mountains are on the western side. The high mountains, especially those in the northern areas, are mostly massive and bold sharp peaks separated by deep, steep-sided valleys (Holland 1976). The steepness of the slopes has periodically been reduced by massive movements of rock and glacial deposits.

Climatic conditions and the rugged terrain limit settlement to the Valemount area and from Bush Lakes south to Golden.

The Arrow Lakes lie between two ranges of the Columbia Mountains trending in a north-south direction, the southern Monashee Range to the west of the basin and the southern Selkirk Range to the east. The norther portions of each range feature high rugged peaks, such as Mount Begbie (El. 2732 m) (8963 ft) and Mount Dawson (El. 3390 m) (11,123 ft). The elevation of the peaks drops in the Lower Arrow Lake area, and the peaks become more rounded.

Habitable land for human settlement in the basin is limited to the narrow remnants of the Columbia valley bottom along the reservoir, creek fans, such as those at Edgewood and Syringa Creek, or alluvial benches such as West Arrow Park, and the flatter sections of tributary valleys such as the Inonoaklin and Incommapleux Rivers.

The Columbia River Valley below the Hugh Keenleyside Dam is characterized by steep gravel banks and flat benches in most places. There are relatively few places where the shore slopes gently down to the river.

3.1.2 Climate

Mica Reservoir

Mica Reservoir lies mainly within the Southeast Interior region, which can be further subdivided into wet and dry sub-regions, namely the Southeast Wet Interior and the Southeast Dry Interior (E.L.U.C. 1974a). The area in the vicinity of Mica Dam is within the Southeast Wet Interior region and has a high annual precipitation of about 1520 mm (60 in) or more, with marked differences in climatic characteristics between valley and mountain elevations. The remainder of the reservoir is within the Southeast Dry Interior region, characterized by the Rocky Mountain Trench which lies in the lee of the Columbia Mountains. It, therefore, receives a lower annual precipitation of about 480 mm (19 in), (of which 60% falls as rain), at Valemount in the north and 560 mm (22 in), (of which 60% falls as rain), at Golden/Donald in the south. Mean daily temperatures in the Mica Reservoir region range from about 17°C (63°F) maximum in July in the valley bottoms to about -11°C (12°F) in January (E.L.U.C. 1974a). Because of the cold winters, snow accumulation is heavy and influenced strongly by location and elevation. The wetter region between El. 1829 m (6000 ft) and 1920 m (6300 ft) has peak average snow accumulations ranging from 2720 mm (107 in) to 3330 mm (131 in) while areas at similar elevations in the drier southern region receive only 890 mm (35 in) (E.L.U.C. 1974a). Snow accumulations decrease at lower elevations. The frost free period is relatively short (60 to 70 days in Valemount and 70 to 90 days in Golden) (E.L.U.C. 1974b).

Arrow Lake Reservoir

The Arrow Lakes Reservoir lies in a zone of climatic transition (Sigma Resource Consultants Ltd. 1975). The southern section of the reservoir, approximately from Edgewood to Syringa Creek, has a very mild climate, similar to that of the Okanagan. This pocket has a low winter snowfall, low total precipitation, a relatively long frost free period and a warm summer. Total average annual precipitation varies from 1090 mm (43 in) at Revelstoke, to 460 mm (18 in) at Deer Park, and 640 mm (25 in) at Castlegar. The average winter snowfall declines from about 4120 mm (162 in) at Revelstoke to about 940 mm (37 in) at Deer Park, rising again to about 1630 mm (64 in) at Castlegar.

The mean daily temperature in January varies from -2°C (28°F) at Deer Park to -6°C (21°F) at Revelstoke, and the mean daily temperature in July varies from a high of 20°C (68°F) at Deer Park to 17°C (63°F) at Nakusp. The frost free period is estimated to increase from 100 days at Revelstoke to 120 at Deer Park (Sigma Resource Consultants Ltd. 1975).

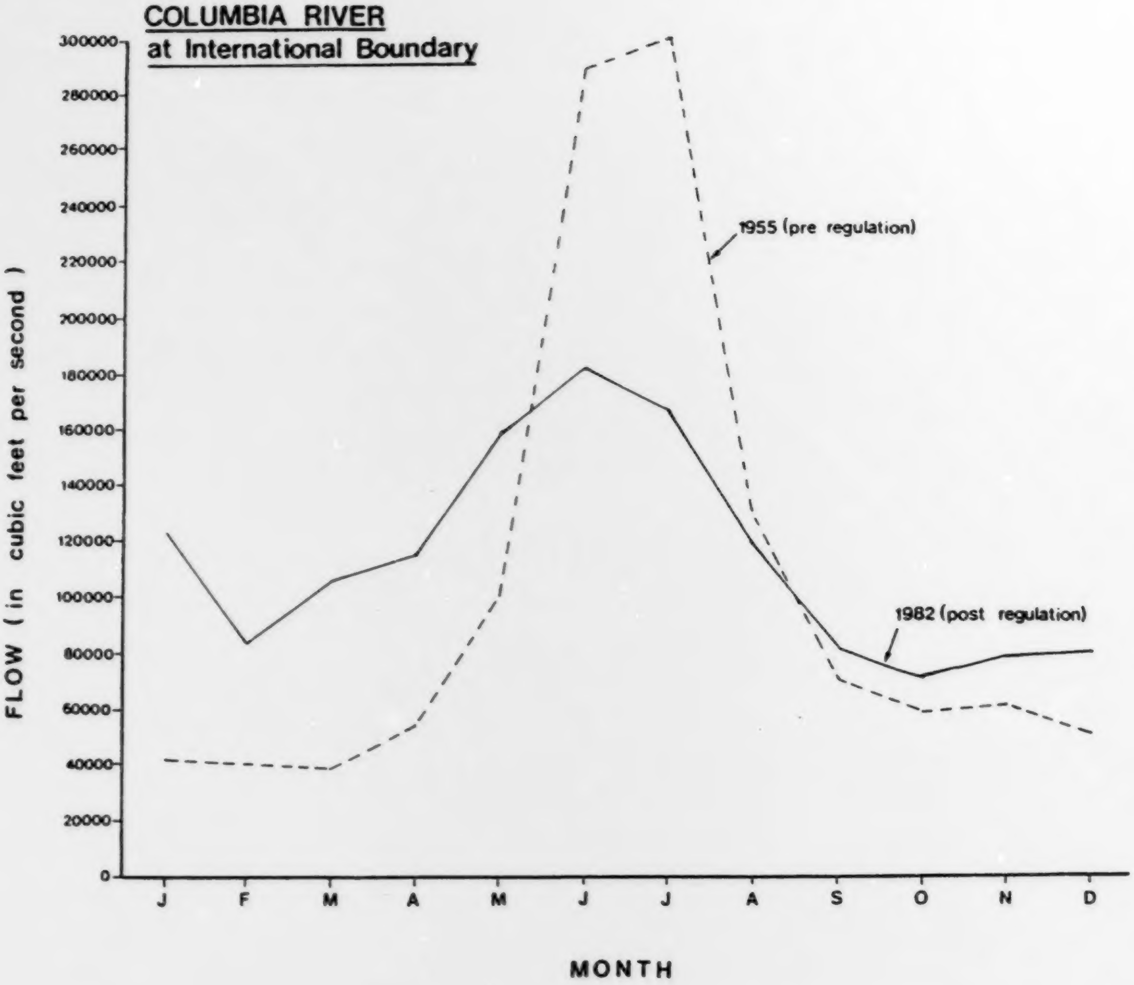
Downstream Area

The area downstream of the Hugh Keenleyside Dam has a total average annual precipitation of approximately 700 mm (28 in). The area experiences a drought period between May and September (Talisman Land Resource Consultants 1984). Snow accumulation is moderate. The area experiences warm summer months with average July temperatures of 21°C (70°F) and fairly mild winters with January temperatures averaging -4°C (25°F). The frost free period is roughly 184 days.

3.1.3 Hydrology and Water Quality

Streamflow in the area is dominated by the snowmelt freshet, peaking in late June or early July. Prior to impoundment, average June flows tended to be approximately ten times greater than minimum mean monthly flows occurring in March or April under natural flow conditions. Progressive regulation of the Columbia River and its tributaries has reduced the range between average June or July flows and average March or April flows to approximately three to one (Figure 3.1). The average annual flow of the Columbia River at the International Boundary (Water Survey of Canada Station No. 08NE058) for the

Figure 3.1 Typical Pre and Post Regulation Flows and Elevations



period of record 1938 to 1982 is approximately 2832 m^3/s (100,000 ft^3/s). The maximum daily flow was recorded on June 11, 1948, at 12,938 m^3/s (456,840 ft^3/s). The minimum daily flow on record of 578 m^3/s (20,400 ft^3/s) occurred December 30, 1945.

Water quality within the Columbia drainage is characterized by the snowmelt runoff throughout the basin and the oligotrophic nature of the reservoirs (discussed further in Section 3.2.2). In addition, with the exception of the free flowing reach downstream of Hugh Keenleyside Dam, there are very few industrial or municipal effluent inputs to the rivers and reservoirs of the basin.

The reach downstream of Hugh Keenleyside Dam was intensively studied during the environmental investigations of the proposed Murphy Creek Hydroelectric Project. As reported in a study prepared by International Environmental Consultants Ltd. (IECL) 1984, the prime water uses in this reach are for the Celgar pulp mill, Westar Timber sawmill, and the City of Castlegar water supply, all of which obtain their water from an intake just upstream of Hugh Keenleyside Dam. In addition, Cominco utilizes water from the river for its smelting and fertilizer complex at Trail (discussed further in Sections 3.3.2 and 3.4.1). The Village of Warfield (population 1840) and the Tadanac subdivision of Trail also obtain their water from the Cominco intake. Effluent from the industrial complexes and from Castlegar's sewage treatment facility is discharged to the Columbia River.

Currently, two water quality concerns have been noted. First, total dissolved gas levels below Hugh Keenleyside Dam are consistently above 110 percent saturation (B.C. Ministry of the Environment 1979). The reported levels are consistently above levels reported to cause acute total gas pressure trauma in fish (Jensen et al. 1986), although no major fish mortalities have been noted to date (Section 3.2.2). These high dissolved gas levels are caused by water plunging to depths of about 20 m from the spillway at Hugh Keenleyside Dam. This does, however, benefit dissolved oxygen levels in this reach of the river, ensuring they are at or near saturation levels throughout the reach.

Second, effluent discharged from the Celgar pulp mill creates water quality problems downstream, especially during periods of minimum flow releases. There is an odour problem at low summer flow levels (A. Brotherston, Senior Environmental Coordinator, BCHPA, pers. comm.). The Murphy Creek environmental assessment (IECL 1984) reported that an odour problem could occur at a dilution level of 1:8200. At no time could the Columbia River provide adequate dilution to totally eliminate the odour problem.

The toxicity of the effluent from the Celgar pulp treatment facilities could induce sublethal toxic effects in fish at river flows of less than 350 m^3/s (12,400 ft^3/s) (IECL 1984). Average values of trace metals and compounds in the Columbia River and federal water quality guidelines are given in Table 3.1. The toxicity of the Celgar pulp mill results in elevated levels of cadmium, cyanide and phenol. Levels of cadmium and cyanide exceed Federal Water Quality Guidelines for protection of aquatic life but are less than Federal Drinking Water Standards (Table 3.1) (IECL 1984). Phenol levels are more than double than the acceptable levels for these Federal reviewing water guidelines (IECL 1984). All other trace metals and toxins are lower than Federal Drinking Water Standards.

Recent legislation has been introduced which requires pulp mills in B.C. to comply with the guidelines for effluent toxicity and effects on water quality outlined in the B.C. Waste Management Act. By 1991, all mills will be required to have secondary effluent treatment capability and reduced emissions of absorbable organic halogens, which are implicated in the production of dioxin-related compounds in the aquatic environment. Accordingly, Celgar is currently preparing for major mill reconstruction to meet these requirements, which will significantly improve downstream water quality.

3.2 Biological Environment

3.2.1 Biogeoclimatic Zone

Mica Reservoir

The Rocky Mountain Trench is almost entirely within the Interior Douglas Fir Biogeoclimatic Zone. This zone lies below about El. 1250 m (4100 ft) and is characterized by a dry climate where spruce and fir are dominant over balsam, cedar and pine, and the forests are heavily influenced by fire (E.L.U.C. 1974b after Krajina 1969). The western portion of the reservoir area, particularly at the confluence of the Canoe and Columbia Rivers, Mica Dam, and the Big Bend, is in the Interior Western Hemlock Zone and is characterized by a comparatively wet climate. Relatively high precipitation, and snow

TABLE 3.1

Average Values of Trace Metals and Compounds in Columbia and Kootenay Rivers

	Hugh Keenleyside Dam ug/L	Brilliant Dam ug/L	U.S./Canada Border ug/L	Federal Water Quality Guidelines: Protection of Aquatic Life ug/L	Federal Water Quality Guidelines: Drinking Water ug/L
Arsenic (diss.)	5.7	5.1	5	10	50
Cadmium (total)	0.5	0.5	0.52	0.2	5
Copper (total)	1.8	1.2	1.1	5	1
Iron (total)	170	120	110	300	50
Lead (total)	1.3	1.3	1.1	30	50
Mercury (total)	0.05	0.05	0.05	0.2	1
Zinc (total)	6.4	5.8	12	30	5000
Cyanide	10	---	10	5	200
Phenol	2.4	2	2.8	1	1

Source: International Environmental Consultants Ltd. (IECL) (1984) accumulation produces a heavy forest cover of cedar and hemlock with mountain hemlock appearing at high elevations. Land between El. 1250 m (4100 ft) and 2150 m (7054 ft) is classified the Engelmann Spruce-Subalpine Fir Zone and is characterized by a wet climate with heavy snowfall. A Boreal White and Black Spruce Zone, characterized by a cold, dry climate with limited tree growth, also occurs at the head of some of the eastern valleys.

Arrow Lakes Reservoir

Land at elevations below about 1250 m (4100 ft) in the vicinity of the Arrow Lakes is classified as the Interior Western Hemlock Biogeoclimatic Zone characterized by hemlock and red cedar (Krajina 1969). This zone is subdivided into two distinct subzones, the Drier (Western Larch) and Wetter (Western Hemlock) Subzones. The former occurs in the Lower Arrow Lakes region and merges into the latter in the central region. Land at elevations above 1250 m (4100 ft) is within the Engelmann Spruce-Subalpine Fir Zone, characterized by Engelmann spruce, lodgepole pine and subalpine fir.

Downstream Area

As in the Arrow Lakes Reservoir region, the land surrounding the Columbia River below Hugh Keenleyside Dam lies in two biogeoclimatic zones, the Interior Western Hemlock Zone and the Engelmann Spruce-Subalpine Fir Zone. The former extends from the valley bottoms to an average elevation of about 1250 m (4100 ft). From there, the Engelmann Spruce-Subalpine Fir Zone extends to the treeless Alpine tundra Biogeoclimatic Zone at an average elevation of approximately 2250 m (7382 ft).

3.2.2 Fish and Fish Habitat

Mica Reservoir

Information relating to reservoir fish and fish habitat was obtained primarily from two pre-impoundment fisheries resource studies conducted by the B.C. Ministry of Environment, Fish and Wildlife Branch (Maher 1961; Peterson and Withler 1965a), the results of a limnological study conducted by B.C. Hydro as part of the Revelstoke Reservoir aquatic monitoring program (Fleming and Smith 1988; 1989), a stream survey report from the B.C.

Ministry of the Environment (Tredger 1977) and the results of two stream surveys conducted by Triton in October, 1988 and June, 1989.

General Limnology

The reservoir is described as being a deep, cold, temperate lake which develops a weak thermocline between 24 and 50 m (78 and 160 ft) (Fleming and Smith 1988). There is some question as to the stability of the thermocline in the reservoir as water is drawn from its hypolimnion. Hypolimnetic drawdown can drastically alter the thermal regime of a reservoir as warmer epilimnetic waters replace the displaced cold hypolimnetic waters lost to outflow. Vertical heat advection due to outflow may cause gradual warming of the reservoir down to the depth of the intake. However, under the current operating regime, this has not been observed to date (H. Smith, Environmental Planning, BCHPA, pers. comm., 4 July 1989).

The lake is nutrient poor (ultra-oligotrophic), and low in biological productivity. Chlorophyll a values ranged between 0.5 and 2.2 mg/m^3 from March through October for the years 1984 to 1986 (Fleming and Smith 1988). Available data on dissolved oxygen concentrations (Fleming and Smith 1988) indicate that concentrations vary little with depth even during thermal stratification. This reflects the oligotrophic nature of the lake and the subsequent low biochemical oxygen demand in the deeper waters. The dominant zooplankters (95% of total abundance) in this lake were the Cladocerans (Fleming and Smith 1988).

Fisheries Resources

Maher (1961), Peterson and Withler (1965a) and Fleming and Smith (1988, 1989) identified seven species of sport fish as being common to the reservoir area (Table 3.2). Historically, only three sport fish, rainbow trout, Dolly Varden char and mountain whitefish, were present in significant numbers. These three species were the most important and abundant sport fish of the region prior to impoundment. Kokanee were introduced in 1982 (Bob Lindsay, Regional Fisheries Biologist, Nelson, B.C., pers. comm., April 20, 1989). Six species of non-sport fish have also been identified.

TABLE 3.2

Probable[1] Fish Species Assemblage of Mica Reservoir and Tributary Streams[2]

Common Name	Scientific Name
Sport Fish	
Kokanee	**Oncorhynchus nerka** (Walbaum)
Rainbow Trout	**Salmo gairdneri** (Richardson)
Dolly Varden[3]	**Salvelinus malma** (Walbaum)
Mountain whitefish	**Prospoium williamsoni** (Girard)
Burbot	**Lota lota** (Linnaeus)
Eastern brook trout	**Salvelinus fontinalis** (Mitchill)
Yellowstone cutthroat trout	**Salmo clarki lewisi** (Girard)
Non-Sport Fish	
Slimy sculpin	**Cottus cognatus** (Richardson)
Pygmy whitefish	**Prosopium coulteri** (Eigenmann and Eigenmann)
Peamouth chub	**Mylocheilus caurinus** (Richardson)
Longnose dace	**Rhinichthys cataractae** (Valenciennes)
Longnose sucker	**Catostomus catostomus** (Forster)
Largescale sucker	**Catostomus machrocheilos** (Girard)
Redside shiner	**Richardsonius balteatus** (Richardson)
Northern squawfish	**Ptychocheilus oregonensis** (Richardson)

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[1] No detailed fisheries studies have been conducted on this reservoir. Some of these species may have disappeared while others may have been introduced.

[2] Data from pre-impoundment study (Peterson and Withler 1965), creel surveys (Fleming and Smith 1988) and information from a stream survey conducted by Envirocon in October, 1988.

[3] Historically, this fish has been referred to as Dolly Varden. However, some of the recent literature refers to this species as the bull trout - Salvelinus confluentus (Suckley). To be consistent with historical data, this species is referred to as Dolly Varden throughout this report.

To date, three surveys of fish in Mica Reservoir have been carried out by B.C. Hydro (Smith 1986; Fleming and Smith 1988 and 1989). The proportion of the catch of kokanee in the gillnet test fishery in Mica Reservoir increased dramatically from 26% in 1985 (Smith 1986) to 65% in 1986 (Fleming and Smith 1988). However, it decreased again in 1987, substantially, to 30%. This variability in catch may be due to the cyclic nature of abundance found in virtually all species of salmonid, or it may be due to the fact that these data were obtained from a single site and may not be an accurate representation of the lake's fish population.

The species composition of the combined catch during gillnet test fishing conducted on Mica Reservoir on two separate dates, 24 June and 16 October 1986 was six rainbow trout (8%), five Dolly Varden (7%), 48 kokanee (65%), 13 mountain whitefish (18%), one longnose sucker (1%), and one peamouth chub (1%).

Rainbow trout and kokanee fish condition factors (an index of the robustness of individual fish) were 1.15 and 1.39, respectively (Fleming and Smith 1988). These are very similar to condition factors for similar species in other lakes in the northwest (where mean condition factors range from 1.13 on Vancouver Island to 1.46 in a small lake in Oregon) suggesting that the productivity level of the reservoir is sufficient to produce robust fish despite its oligotrophic state.

While estimates of angler catch per unit effort (number of fish per rod-hour) are not available, the outcome of a fishing derby monitored by BCHPA personnel during the period 20-22 June 1986 showed that rainbow trout, Dolly Varden and kokanee are the species most often caught by anglers. Catch success for each species occurred in the above order. This is not consistent with the data from the gill net test fisheries for 1986 and 1987 which showed that kokanee were more abundant than the other major sport fish species (Fleming and Smith 1988 and 1989). Whether this reflects fishing effort being directed primarily toward the other two species (rainbow trout and Dolly Varden char, which is likely since fishing derbies are often structured around the practice of catching the biggest fish), or that the quality of the kokanee fishing experience in this lake is yet to be discovered, is undetermined.

Prior to the creation of the reservoir, Peterson and Withler (1965a) surveyed twenty-seven streams tributary to the proposed reservoir basin (Appendix 1). Of these, no fish were found in five (Potlatch, Boulder, Unnamed, Yellowjacket and Bulldog Creeks; see Figure 2.2). Rainbow trout were captured in twelve streams, Dolly Varden were present in eight and mountain whitefish were found in all except the five fishless streams mentioned above.

The results of two surveys of twenty-eight streams tributary to the reservoir (many of them the same as those sampled by Peterson and Withler) undertaken by Triton Environmental Consultants Ltd. in October, 1988 and June, 1989 are presented in Table 3.3. Streams were assessed on the basis of accessibility to migrating fish (at the observed reservoir levels of 742.8 m (2437 ft) in October 1988, and 731.8 m (2400.9 ft) in June 1989); (O. Nagy, Water Survey of Canada, pers. comm. Sept. 6, 1989) and the availability and accessibility of spawning areas (to fish). Presence and/or absence of salmonid juveniles and adults was also documented.

Of the streams surveyed by Triton, only Succour Creek was found to contain populations of rainbow trout (14 juveniles captured in minnow traps and 7 adults angled). It was not ascertained whether lake resident rainbow trout enter this stream to spawn and subsequently rear, or whether the rainbows observed in the stream were resident fish.

Dolly Varden juveniles (4 in all) were captured in the Canoe (2) and Bush (1) Rivers and in Dave Henry Creek (1). Again, it was not possible to ascertain whether lake resident members of this species entered these streams to spawn or whether they were stream resident fish.

Mountain whitefish (schools of up to 50 fish) were observed in only five of the streams surveyed in 1988 (Table 3.4). However, it is likely that they are still present in virtually all of the major streams of the region as was previously indicated by Peterson and Withler (1965a; Appendix 1).

Spawning kokanee salmon (several hundreds) were observed in many of the small, non-glacial, runoff streams in the southern portion of the reservoir (Bush Arm, Figure 3.2) and in the delta of the cold, glacier-fed Bush River. No kokanee were found in any of the other larger, cold glacial streams.

TABLE 3.3

Results of Aerial and Ground Surveys of Streams Tributary to Mica Reservoir[1]

Stream	Glacial Origin	Survey Type Aerial	Survey Type Ground	Fish Species[2] Present	Spawning Areas Present	Accessible to Spawners
Bulldog Cr.	no	yes	yes	none	none	yes
Yellowjacket Cr.	no	yes	yes	none	none	yes
Dave Henry Cr.	no	yes	yes	DV	none	yes
Packsaddle Cr.	no	yes	yes	none	none	yes
Canoe R.	yes	yes	yes	DV, LL	some[4]	yes
Foster Cr.	yes	yes	no	N/A[3]	some	yes
Encampment Cr.	yes	yes	no	N/A	none	yes
Nagle Cr.	yes	yes	no	N/A	some	yes
Potlatch Cr.	yes	yes	no	N/A	none	no
Yellow Cr.	yes	yes	no	N/A	none	no
Bachelor Cr.	yes	yes	no	N/A	abundant	yes
Gold R.	yes	yes	no	N/A	some	yes
Beaver R.	yes	yes	no	N/A	abundant	yes
Columbia R.	yes	yes	yes	Kok, DV	abundant	yes
Succour Cr.	no	yes	yes	Kok, DV, RBT, BT	abundant	yes
Hope Cr.	yes	yes	yes	MW	few	yes
Goodfellow Cr.	yes	yes	yes	MW	few	yes
Valenciennes R.	yes	yes	yes	MW	some	yes
Bush R.	yes	yes	yes	Kok, DV, MW	abundant	yes
Prattle Cr.	yes	no	yes	none	none	yes
Chatter Cr.	yes	no	yes	none	none	yes
Km 105 Cr.	no	no	yes	Kok	some	yes
Sullivan R.	yes	yes	no	N/A	some	yes
Kinbasket R.	yes	yes	no	N/A	some	yes
Tsar Cr.	yes	yes	no	N/A	none	yes
Cummins R.	yes	yes	no	N/A	some	yes
Wood R.	yes	yes	yes	MW	abundant	yes
Hugh Allen Cr.	yes	yes	no	N/A	some	yes

[1] Survey dates were October 21 - 27, 1988

[2] DV = Dolly Varden; RBT = rainbow trout; Kok = kokanee; MW = mountain whitefish; BT = brook trout; LL = Lota lota (Burbot)

[3] N/A = data not available as streams not sampled for fish

[4] Few = 1 to 3 intermittent spawning areas between 10 and 50 m (30 and 160 ft) in length; Some = 4 to 10 intermittent spawning areas between 10 and 50 m (30 and 160 ft) in length; Abundant = Continuous lengths of spawning gravels (some up to 1 km (0.6 mi)) or more than 10 intermittent spawning areas between 10 and 50 m (30 and 160 ft) in length.

TABLE 3.4

Average Water Temperatures During March - June and September - October and Maximum Summer Temperatures (August) in Selected Streams Tributary to Mica Reservoir[1]

Stream	March - June °C (°F)	September - October °C (°F)	August Maximum °C (°F)
Canoe River	1.2 - 7.3 (34.0 - 45.1)	6.0 - 2.1 (43.0 - 36.0)	10.0 (50.0)
Gold River	1.7 - 5.7 (34.3 - 42.3)	4.5 - 3.0 (40.0 - 37.4)	7.0 (44.6)
Wood River	3.2 - 8.1 (37.8 - 46.6)	7.2 - 5.4 (45.0 - 42.0)	12.0 (53.6)
Blaeberry River	5.0 - 11.3 (41.0 - 52.3)	12.0 - 8.3 (53.6 - 47.0)	15.5 (60.0)

[1] Source: Environment Canada Water Temperatures for B.C. and Yukon Territory. Stream data are available only for these four streams.

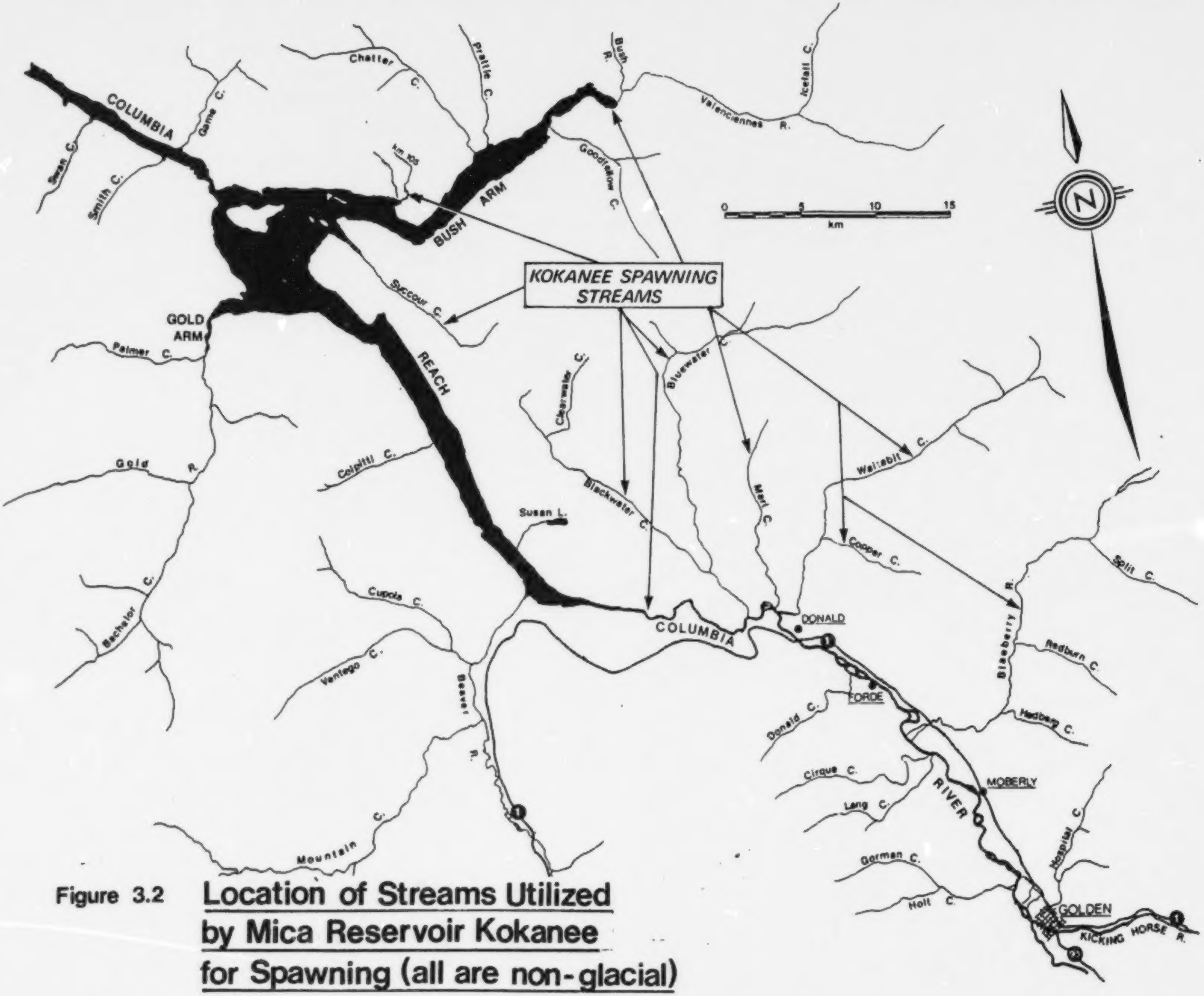
KOKANEE SPAWNING STREAMS
COLUMBIA
BUSH ARM
REACH
GOLD ARM
COLUMBIA RIVER
Chatter C.
Prattle C.
Bush R.
Icefall C.
Valenciennes R.
Goodfellow C.
Game C.
Swan C.
Smith C.
km 105
Succour C.
Palmer C.
Gold R.
Colpitti C.
Clearwater C.
Bluewater C.
Blackwater C.
Mert C.
Waitabit C.
Cooper C.
Susan L.
Bachelor C.
Cupola C.
Vantage C.
Beaver R.
Mountain C.
Donald C.
Cirque C.
Lang C.
Gorman C.
Holt C.
Hospital C.
Blaeberry R.
Redburn C.
Hedberg C.
Split C.
DONALD
FORDE
MOBERLY
GOLDEN
KICKING HORSE R.
0 5 10 15
km
N

Figure 3.2 Location of Streams Utilized by Mica Reservoir Kokanee for Spawning (all are non-glacial)

Fish Habitat

The reservoir basin is steep-sided with very little littoral development. Shallow areas are found in only four areas of the lake: several hundred hectares of flats at the extreme north end of Canoe Reach near Valemount; large mudflats located between an unnamed island in Columbia Reach, slightly north of Gold Arm (Figure 3.2) and the reservoir shoreline; a wide, braided delta at the head of Bush Arm; and an area of sandbars and flats at the extreme south end of the reservoir where the Columbia River enters.

The paucity of shallow areas and the extensive annual fluctuations in water level (up to 47 m (155 ft) between 707 m (2320 ft) and 754 m (2475 ft)) severely limit the extent of littoral development in the lake. With the exception of some seasonal regrowth of vegetation on the Valemount flats, the drawdown zone of the reservoir provides little habitat for fish. The extensive water level fluctuations probably eliminate most benthic invertebrate production and the likelihood of lake shoreline spawning.

Essentially, the only habitat available to fish in this reservoir is the open-water pelagic zone (which, as is typical of many B.C. reservoirs, is relatively unproductive), and spawning and rearing habitat located in the streams tributary to the reservoir.

The timing of the spawning runs and the locations of spawning grounds of the rainbow trout, Dolly Varden and mountain whitefish that reside in Mica Reservoir are unknown at this time. The timing of the runs, however, should be similar to those of fish of the same species in other areas of the Columbia River system.

Above reservoir full pool, most of the streams tributary to the reservoir are precipitous and inaccessible to migrating fish. Of those streams accessible to migrating and/or spawning fish (Table 3.4 and Figure 2.2), just over half (60%) have moderate grade above the flood line and contain spawning habitat suitable for the salmonid species present in the lake. These include; the Canoe, Wood, Cummins, Kinbasket, Sullivan, Bush, Valenciennes, Gold, Beaver and Upper Columbia Rivers and Hugh Allen, Nagle, Bachelor, Succour, Km 105, Goodfellow, Hope and Foster Creeks.

As a result of reservoir flooding eliminating barriers to upstream migration of fish (such as water falls), significant amounts of new spawning habitat were made accessible in the Wood and Beaver Rivers and Foster Creek. However, the extent to which this habitat is utilized by any of the salmonid species in the reservoir has not been documented. The barriers in Wood and Beaver Rivers and Foster Creek were all exposed during Triton's June survey when reservoir elevations were around 735 m (2410 ft) (O. Nagy, Water Survey of Canada, pers. comm., September 6, 1989).

To provide good habitat for fish, a stream should have: 1) a fairly stable flow of clean water; 2) an adequate food supply; and 3) spawning areas with gravels 10 cm (6 in) in diameter or less.

By standards 1) and 3), (food supply was not assessed in either Triton's survey or that of Peterson and Withler), most of the streams tributary to Mica Reservoir provide relatively poor habitat for fish. As discussed above, many are small, precipitous in grade, ephemeral and have little or no spawning habitat.

With a few exceptions (Bulldog, Yellowjacket, Dave Henry, Packsaddle and Succour Creeks, Table 3.4), the more accessible streams are larger, glacial in origin, heavily silted and very cold throughout the year. They provide excellent habitat for mountain whitefish and Dolly Varden, but they may be too cold to support populations of rainbow trout or kokanee. The smaller, non-glacial streams may be more suitable for trout and kokanee production.

Rainbow trout spawning in the Columbia system generally takes place in clean, well oxygenated waters in April through June at water temperatures between 10 and 15.5°C (50 and 60°F). Dolly Varden spawn from October to early November in rivers of moderate current with a bottom of medium to large gravel and temperatures near 7.8°C (46°F). Kokanee spawn in the fall, generally during September and October in water temperatures ranging from 5.0 - 10.5°C (41 - 51°F). The mountain whitefish may spawn from October through to February in inlet streams or on gravel shallows in lakes (McPhail and Lindsey 1970) but little else is known of their spawning habits.

Water temperatures in the large glacial streams tributary to the reservoir (i.e. Canoe, Gold and Wood Rivers; Table 3.3) average less than 8°C (46.4°F) in March through June and less than 7.5°C (45°F) in September through October. In fact, temperatures in these streams appear to only reach temperatures approaching the minimum requirement for spawning rainbow trout (10°C (50°F)) in August long after the spawning period is over. Similarly, these streams may be too cold (usually less than 7.0°C (45°F)) to support spawning kokanee during the fall months (Table 3.3). Kokanee were observed to enter streams tributary to Mica reservoir to spawn (Figure 3.2) on September 12, 1988 (Rob Geiner, local logger, pers. comm., October 23, 1988). Kokanee spawning was still under way in October (1988) during the Triton survey but it was in the final stages. Water temperatures in these streams at that time were around 7°C (45°F).

In contrast, the non-glacial streams tributary to the reservoir (such as the Blaeberry River; Table 3.3) have ideal spawning temperatures for rainbow trout in late May to early June. Also, the average temperature in the non-glacial streams in the vicinity of Bush Arm, where kokanee were observed to be spawning, was 7.5°C (45°F). These data suggest that the large, glacial streams of this system are unsuitable as spawning streams for the lake resident rainbow trout and kokanee populations.

Sixteen of the twenty-eight streams surveyed by Triton had significant (some to abundant) amounts of spawning habitat accessible to migrating fish when the reservoir elevation was about 742 m (2434 ft). Two, Hope and Goodfellow Creeks, had only isolated patches of spawning gravels and ten had none (Table 3.3). (For the purposes of this discussion, "significant amounts" of spawning habitat was arbitrarily defined as accessible sections of stream greater than 50 m (160 ft) in length composed almost entirely of gravels suitable for spawning (10 cm (3 in.) or less in diameter)).

Few fish were captured during the ground surveys of streams tributary to Canoe Reach (Figure 2.2) despite extensive pole seining and electroshocking, suggesting that many of the streams along this portion of the reservoir are not used by lake resident salmonids for spawning or rearing. This is consistent with the observation that most of these streams are precipitous and boulder- strewn. Foster Creek, one of the few streams tributary to Canoe Reach which appears to contain large amounts of excellent spawning habitat, has a waterfall at its mouth which would severely restrict upstream migration for fishes at reservoir levels less than about 735 m (2410 ft).

Several of the larger streams on the west side of the reservoir (Bachelor Creek, Gold and Beaver Rivers; Figure 2.2) contain what appears to be excellent spawning habitat which would have been accessible to fish at the reservoir level observed in 1988, although no fish were observed at the time of the survey. However, at lower reservoir levels (such as the level observed in July, 1989) (735 m (2410 ft)), access for fish migrating out of the lake to spawn on potential spawning grounds in the Beaver River is restricted by an impassable waterfall approximately 1 km (0.6 mile) upstream from its confluence with the reservoir.

Along the east side of the reservoir, there are several large, glacier-fed streams (Sullivan, Kinbasket, Cummins, and Wood Rivers and Tsar and Hugh Allen Creeks; Figure 2.2). With the exception of Wood River which, as previously noted, has a migration barrier near its mouth, these streams are accessible to upstream migrating fish at all reservoir levels. The only salmonid species of record in each of these streams prior to impoundment was mountain whitefish (Peterson and Withler 1965a). This is consistent with observations made by Triton personnel in 1988.

Arrow Lakes Reservoir

Information relating to the limnology and fisheries of the Arrow Lakes Reservoir was obtained primarily from a fisheries inventory and impact assessment study conducted by R L and L Environmental Services (Ash et al. 1982); a limnological study of four reservoirs in B.C. (including Arrow Lakes) conducted by B.C. Research in 1977; water quality information from the B.C. Ministry of the Environment (1979); several B.C. Fish and Wildlife Branch Reports on the sport fishery of the Upper and Lower Arrow Lakes (Lindsay 1977, 1978, and 1979; Lindsay and Seaton 1978); results of limnological studies conducted by B.C. Hydro as part of the Revelstoke Project (Fleming and Smith 1988 and 1989) and; two pre-impoundment fisheries resource studies conducted by the B.C. Fish and Wildlife Branch (Maher 1961; Peterson and Withler 1965b).

General Limnology

The Arrow Lakes are low in total ions, total dissolved solids, colour, turbidity, nutrients and biological productivity. Chlorophyll a values throughout the year range from a winter low of 1.7 mg/m^3 to a summer high of 3.5 mg/m^3 with a mean of 2.9 mg/m^3 (B.C. Ministry of the Environment 1979), suggesting that this lake is slightly more productive than Mica Reservoir.

The lakes stratify thermally during the warm summer months. Stratification begins to break down in September. Dissolved oxygen levels remain high throughout the water column all year long reflecting the oligotrophic nature of these two lakes.

While cladocerans are the predominant zooplankters in Mica Reservoir the zooplankton of the Arrow Lakes is dominated by copepods (92.1% of total) (Fleming and Smith, 1988). This difference may, in part, be attributable to the fact that kokanee, a highly planktivorous fish that feeds largely on cladocerans, is native to the Arrow Lakes region, whereas kokanee were only been recently (1985) introduced to Mica Reservoir (B. Lindsey, Regional Fisheries Biologist, Nelson, B.C., pers. comm., April 20, 1989). Mysis relicta, a large invertebrate, was introduced into the Arrow Lakes in 1967 to provide a food source for juvenile trout (Ash et al. 1982). However, no studies have been conducted to document their abundance or effect on fish production.

Fisheries Resources

Maher (1961), Peterson and Withler (1965b) and Fleming and Smith (1988 and 1989) have identified nine species of sport fish as being common to the Arrow Lakes (Table 3.5). Fifteen species of non-sport fish have also been identified.

To date, three surveys of the fish populations in the Arrow Lakes Reservoir have been carried out by B.C. Hydro (Smith 1986; Fleming and Smith 1988 and 1989). The results of gillnet test fishing on Upper Arrow Lake on two separate dates, 18 June and 19 October, 1986 set the species composition of the combined catch at two rainbow trout (2%), 19 Dolly Varden (now referred to as bull trout) (22%), 40 kokanee (47%), one burbot (1%), two mountain whitefish (2%), 14 northern squawfish (16%), three each of largescale suckers (4%) and peamouth chub (4%) and one each of longnose sucker (1%) and carp (1%).

Rainbow trout and kokanee fish condition factors were 1.00 and 1.05 (Fleming and Smith 1988) in Upper Arrow Lake. The condition factor for these two fish species are

TABLE 3.5

Probable[1] Fish Species Assemblage of Arrow Lakes Reservoir and Tributary Streams[2]

Common Name	Scientific Name
Sport Fish	
Mountain whitefish	**Prospoium williamsoni** (Girard)
Lake whitefish	**Coregonus clupeaformis** (Mitchill)
Eastern brook trout	**Salvelinus fontinalis** (Mitchill)
Yellowstone cutthroat trout	**Salmo clarki lewisi** (Girard)
Rainbow Trout	**Salmo gairdneri** (Richardson)
Dolly Varden char	**Salvelinus malma** (Walbaum)
Kokanee	**Oncorhynchus nerka** (Walbaum)
Burbot	**Lota lota** (Linnaeus)
White sturgeon	**Acipenser transmontanus** (Richardson)
Non-Sport Fish	
Pygmy whitefish	**Prosopium coulteri** (Eigenmann and Eigenmann)
Largescale sucker	**Catostomus machrocheilos** (Girard)
Longnose sucker	**Catostomus catostomus** (Forster)
Bridgelip sucker	**Catostomus columbianus** (Eigenmann and Eigenmann)
Northern squawfish	**Ptychocheilus oregonensis** (Richardson)
Redside shiner	**Richardsonius balteatus** (Richardson)
Carp	**Cyprinus carpio** (Linnaeus)
Peamouth chub	**Mylocheilus caurinus** (Richardson)
Lake chub	**Couesius plumbeus** (Agassiz)
Leopard dace	**Rhinichthys falcatus** (Eigenmann and Eigenmann)
Longnose dace	**Rhinichthys cataractae** (Valenciennes)
Prickly sculpin	**Cottus asper** (Richardson)
Torrent sculpin	**Cottus rhotheus** (Smith)
Slimy sculpin	**Cottus cognatus** (Richardson)

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[1] The list of species provided in this table is from pre-impoundment studies and studies in tributary streams. No detailed fisheries studies have been conducted in the reservoir and, as such, some species may have disappeared, be confined to tributaries or have been introduced.

[2] Based on information provided in the pre-impoundment study (Peterson and Withler 1965); creel surveys (Lindsay 1978; Lindsay and Seaton 1978); studies of Upper Arrow Lake tributaries (Steigenberger and Elson 1976; B.C. Ministry of the Environment 1979; McPhail and Murray 1979).

considerably lower than for the same species in the less productive Mica Reservoir (1.15 and 1.39, respectively) and below the lowest mean condition factor recorded in the northwest for unproductive lakes on Vancouver Island (1.13) which suggests that fish in this lake are suffering from a possible diet restriction.

Creel censuses conducted between 1970 and 1977 on the Upper and Lower Arrow Lakes showed that angling effort was divided equally between the rainbow trout/Dolly Varden char fishery and the kokanee fishery (Lindsay and Seaton 1978). Creel censuses in 1978 showed that only 14% of the total angling effort was being directed at the trout/char fishery while kokanee was attracting 86% of the effort (Lindsay and Seaton 1978). This suggested that the increase in effort towards kokanee was a reflection of reduced abundances of rainbow trout and Dolly Varden char in the lakes.

Virtually all of the streams tributary to both Upper and Lower Arrow Lakes support resident and/or migratory spawning populations of trout (rainbow, eastern brook, cutthroat), Dolly Varden char, and/or kokanee (Lindsay 1978; Lindsay and Seaton 1978; Seaton 1978).

Fish Habitat

Little is known about the extent and quality of lacustrine fish habitat available to fish of the Arrow Lakes. However, there are several large (several hectares in size) areas of shallow water and/or exposed mudflats interspersed with small pools and channels that could provide some rearing and/or shoreline spawning habitat for fish. These are the section of Upper Arrow Lake extending from Revelstoke to Arrowhead; the delta of the Incomappleaux River; and a broad expanse of shallow littoral gravels extending from Nakusp in the north, through the Narrows to Edgewood in the south (Figures 2.3 and 2.4).

The extent to which these flats and shallows are utilized by fish for spawning or rearing is largely unknown. Extensive beach seining in two shallow areas by Triton personnel in October, 1988 (10 sets with a 50 m seine along one beach at the mouth of Mackenzie Creek) resulted in the capture of only 10 juvenile whitefish, 1 small sculpin and 1 juvenile longnose dace, suggesting that these areas may be used for rearing but not extensively.

The expansive shallow zone in the vicinity of Nakusp had a substrate composition that consisted almost entirely of spawning-sized gravels (2-10 cm (1-6 in)). However, it is not known whether fish utilize the area for spawning.

The shallow areas of most large deep lakes are generally the most productive zones of the lake. They are usually the areas where one finds the aquatic plants which furnish substrates, refuge and/or food for many aquatic invertebrates and fish. However, in reservoirs, the effects of drawdown are most evident in the littoral zone where processes such as erosion, resuspension, entrainment and redistribution of sediments can result in primary productivity being greatly reduced, or eliminated. Such was the case for the Arrow Lakes. Examination of the substrate in all of the shallow littoral areas of the two lakes yielded no evidence of macrophyte or periphyton growth in these areas (in October 1988). Both submerged and exposed areas in this reservoir were completely devoid of aquatic plants. This barren habitat likely provides little productive rearing habitat for fish.

All streams tributary to both Upper and Lower Arrow Lakes are cool (maximum summer temperatures range between 13 and 19°C (55 to 75°F) (Lindsay 1978), clear-flowing, melt-water or run-off streams. Spawning of lake resident fish occurs in the lower reaches of almost all of these streams over distances ranging from 10 m (30 ft) to as much as 6 km (4 mi) upstream from the point at which the stream meets the lake (Lindsay 1977; Seaton 1978). In the majority of cases, spawning is limited to within a few hundred metres of the lake.

Virtually all of the streams tributary to the Arrow Lakes meet at least two criteria (over at least part of their length) for streams providing good habitat for fish: i.e. 1) they have a fairly stable flow of clean water; and 2) they have significant amounts of spawning habitat. Unfortunately, due to the nature of the morphometry of the reservoir basin, many of the streams have natural obstructions (falls) within a few hundred metres of the lake which are impassable barriers to fish attempting to migrate farther upstream, placing a limit on total fish production of the lake system.

Above these natural barriers in several streams, there are stream reaches that contain excellent spawning and rearing habitat ranging in length from several hundred metres to several kilometres (Seaton 1978). However, logistical problems preclude enhancement measures to make this habitat available to fish migrating from the Arrow Lakes. Of thirty-one streams tributary to Lower Arrow Lake assessed on the basis of their enhancement potential, six were deemed to be suitable candidates for enhancement measures. They are: the Inonoaklin River; the Snow - Burton Creek complex, and; Eagle, Taite, Deer and Mosquito (also known as Arrow Park) Creeks (Figure 2.4; Lindsay and Seaton 1978).

As rainbow trout stocks declined from pre-impoundment levels due to the creation of this reservoir and those further upstream, which blocked access to spawning habitat, two enhancement projects have been constructed with funding from BCHPA; a kokanee and rainbow trout spawning facility at Hill Creek managed by the provincial Fish and Wildlife Branch and a kokanee spawning facility at Bridge Creek maintained by Revelstoke residents (Figure 3.3). The Hill Creek Hatchery was a result of compensation for creation of the Revelstoke Reservoir. In addition, BCHPA and the Revelstoke Rod and Gun Club enhanced the lower portion of Moses Creek in 1989. These enhancement measures have done much to offset the decline in sport fish populations experienced after the creation of this and upstream reservoirs.

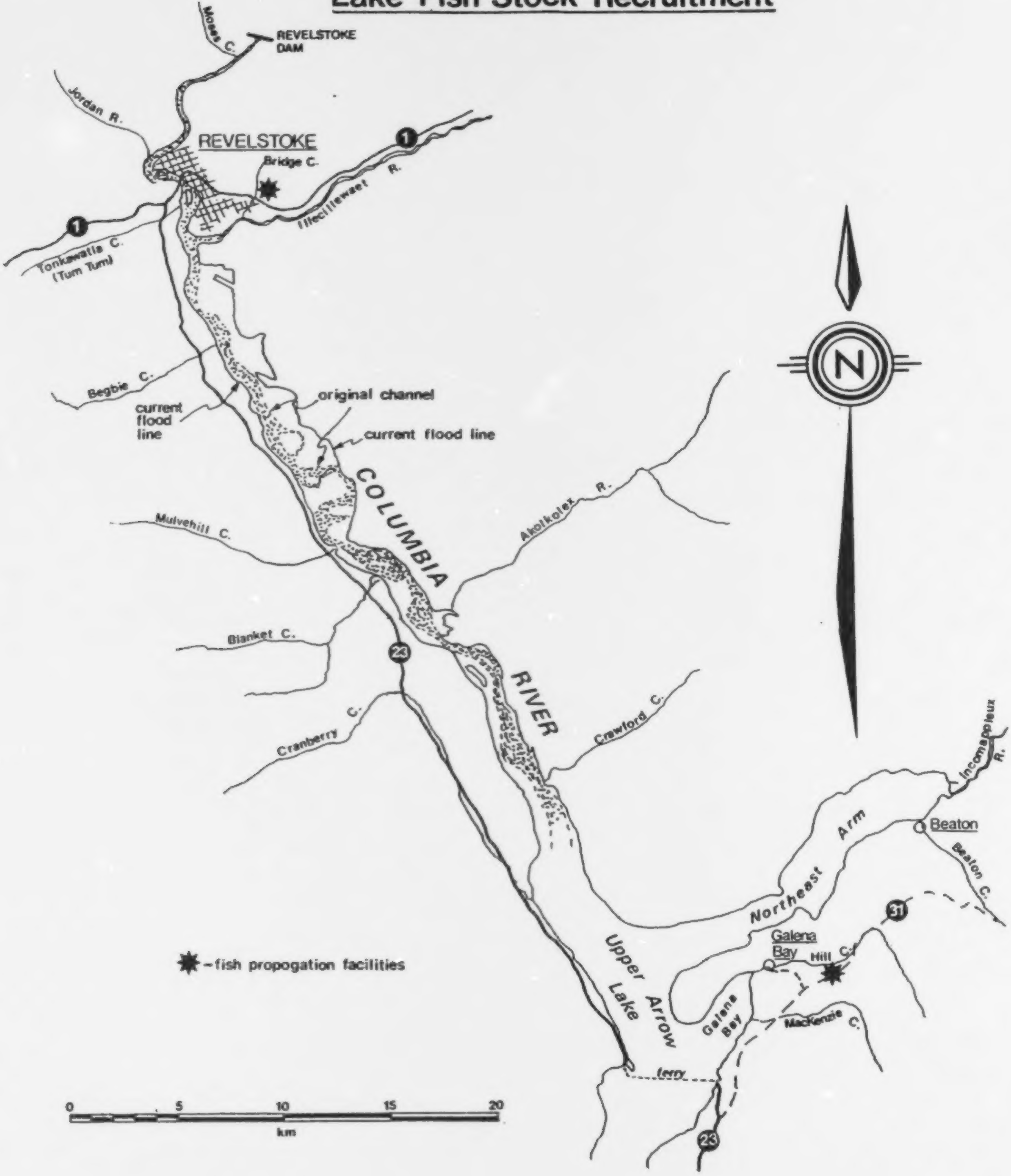
Downstream Area

General River Limnology

Discharges to the Columbia River downstream of Hugh Keenleyside Dam in winter average about 2100 m^3/s (74,000 ft^3/s) and subsequently decline to a low in March-April of about 360 m^3/s (12,700 ft^3/s). Discharges increase again through spring and are relatively stable through July-August, averaging about 865 to 1500 m^3/s (30,600 to 53,000 ft^3/s). Flows decrease slightly and stabilize through September-November reaching a low in the fall averaging 1000 m^3/s (35,000 ft^3/s). Subsequently, they increase in winter (Ash et al. 1982). Daily flows can be as high as 2747 m^3/s (97,000 ft^3/s) or as low as 142 m^3/s (5000 ft^3/s).

Water temperatures are lowest in January-February (0.5 - 4.0°C (33 to 40°F)) and gradually increase to maximum levels in July-August (13 - 19.5°C (55 to 67°F). In most years, ice does not form on the Columbia River between the dam and the City of Trail (Ash et al. 1982).

Figure 3.3 Location of the Two Operational Fish Propagation Facilities for Upper Arrow Lake Fish Stock Recruitment


Moses C.
REVELSTOKE DAM
Jordan R.
REVELSTOKE
Bridge C.
1
Illecillewaet R.
1
Tonkawatla C. (Tum Tum)
Begbie C.
current flood line
original channel
current flood line
COLUMBIA
RIVER
Mulvehill C.
Akolkolex R.
Blanket C.
23
Cranberry C.
Crawford C.
N
Incomappleux R.
Beaton
Beaton C.
Northeast Arm
31
Galena Bay
Hill C.
Upper Arrow Lake
Galena Bay
MacKenzie C.
ferry
23
-fish propogation facilities
0
5
10
15
20
km

With the exception of point source effluents (e.g. Celgar mill), nutrient concentrations (phosphorous and nitrogen) of the waters of the Columbia River are low and reflect the oligotrophic nature of the waters that feed it (Arrow Lakes).

The abundance and distribution of plankton and macroinvertebrates has not been studied in detail. However, there is a continuous supply (during drawdown periods) of food for fish from the reservoir as a result of invertebrate entrainment through or over Hugh Keenleyside Dam, although this benefit is probably confined to the area immediately downstream of the dam. Mysis relicta, which originate from the Arrow Lakes and are transported downstream through the dam are present in the upper section of the Columbia River. The mysids constitute an important food source for fish in the river with heaviest utilization occurring in the vicinity of the dam (Ash et al. 1982).

Fisheries Resources

The Columbia River from Hugh Keenleyside Dam to the U.S. border is inhabited by eight sport fish and 10 non-sport fish species (Table 3.6). Ash et al. (1982) reported that as many as 100,000 fish were captured or observed in one section of the Columbia River alone (between Hugh Keenleyside Dam and Castlegar) during sampling in 1980 and 1981. The majority of these fish were coarse fish species, and were young of the year and yearlings. Forage and coarse fish (especially redside shiners and juvenile suckers) accounted for more than 90% of the total number of fish captured or observed. Of the sport fish species, mountain whitefish were the most abundant (5% of total) followed by kokanee and rainbow trout (no percentage available but described as common) (Ash et al. 1982).

The observed abundance of young fish may indicate the availability of a large amount of high quality rearing habitat in the area between the dam and Castlegar. Alternatively, it may be that many of the young-of-the-year fish that would normally inhabit the reservoir behind the dam are being entrained over (or through) the dam, thus the true numbers of downstream resident fish may be over-estimated. Although entrainment of fish through the dam has been documented (Ash et al. 1982), the extent of this input is unknown.

A mixed sport fishery exists in the river below the dam (B.C. Fish and Wildlife Branch

TABLE 3.6

Fish Species Found in the Columbia River between Castlegar and Hugh Keenleyside Dam, 1980 and 1981[1]

Common Name	Scientific Name
Sport Fish	
Mountain whitefish	**Prospoium williamsoni** (Girard)
Lake whitefish	**Coregonus clupeaformis** (Mitchill)
Rainbow Trout	**Salmo gairdneri** (Richardson)
Dolly Varden char	**Salvelinus malma** (Walbaum)
Kokanee	**Oncorhynchus nerka** (Walbaum)
Burbot	**Lota lota** (Linnaeus)
White sturgeon	**Acipenser transmontanus** (Richardson)
Walleye	**Stizostedion vitreum vitreum** (Mitchill)
Non-Sport Fish	
Largescale sucker	**Catostomus machrocheilos** (Girard)
Longnose sucker	**Catostomus catostomus** (Forster)
Bridgelip sucker	**Catostomus columbianus** (Eigenmann and Eigenmann)
Northern squawfish	**Ptychocheilus oregonensis** (Richardson)
Redside shiner	**Richardsonius balteatus** (Richardson)
Carp	**Cyprinus carpio** (Linnaeus)
Peamouth	**Mylocheilus caurinus** (Richardson)
Longnose dace	**Rhinichthys cataractae** (Valenciennes)
Prickly sculpin	**Cottus asper** (Richardson)
Shorthead sculpin	**Cottus confusus** (Bailey and Bond)

Total number of species: 18

[1] Source: Ash et al. 1982

1981). The species angled for are rainbow trout, Dolly Varden char, kokanee, whitefish and burbot. Local anglers also report the occasional catch of sturgeon, walleye and chinook salmon. Chinook salmon were released into the Roosevelt Reservoir by Washington State Fish and Game in the mid-1970's and may have made their way upstream (B.C. Fish and Wildlife Branch 1981). Three species, rainbow trout, kokanee and Dolly Varden char provide the majority of the sport fishing on the river.

Fish Habitat

The Columbia River between the U.S. border and Hugh Keenleyside Dam can be characterized as being of low gradient and having extensive areas of low water velocity, extensive shallow areas and abundant riparian vegetation.

Immediately below the dam, the river banks are smooth, steeply inclined and about 10 m (30 ft) high. A bedrock outcrop constitutes the north bank. The substrate is predominantly boulder-cobble interspersed with areas of sand and silt. There are very few shallow areas. The morphometry of the stream in this region coupled with the large water level fluctuations precludes the presence of salmonid spawning habitat, but low current velocities, deep water and a source input of food organisms from Lower Arrow Lake combine to provide a high quality rearing habitat.

Farther downstream, the river bank form varies between low and flat and high and steep but the river maintains its low gradient. The shoreline is irregular and covered with fine sand or silt interspersed with organic debris (some large). The water flow can be characterized as placid. However, there are typical relief-induced habitat units of the pool, glide, run and riffle variety. Aquatic vegetation is abundant. There are isolated sand and gravel deposition bars along the length of the river. The extent to which these areas are utilized for spawning is not fully known. The low water velocity, extensive shallow areas and abundant aquatic vegetation probably combine to provide good rearing habitat along the entire length of the river

The quality of available habitat in the area immediately downstream of the dam would most certainly be enhanced by a unilateral input of nutrients, food and fish from the Arrow Lakes to the downstream area. Although the Arrow Lakes are in themselves fairly unproductive, large numbers of lacustrine food organisms would be concentrated behind the dam as a result of entrainment to the area (by currents). These organisms would subsequently be entrained over (or through) the dam and made available to fish downstream.

At present, the only major potential concerns regarding outflows from the Hugh Keenleyside Dam and their effect on downstream fish habitat is the level of dissolved gas supersaturation in the waters immediately downstream of the dam and the possibility of sublethal effects of the effluent from Celgar pulp mill.

The Columbia River below the Hugh Keenleyside Dam has been identified as having the highest total dissolved gas (TDG) concentrations of thirty-five major lakes and rivers examined in B.C. (Clark 1977). TDG concentrations as high as 144% saturation have been recorded (17 August 1976). The TDG saturations were highest in the section of the Columbia River between Hugh Keenleyside Dam and the Kootenay River. Concentrations of dissolved gas of the magnitude observed could cause significant mortalities in salmonids (Clark 1977). However, despite considerable effort to document incidences of gas bubble disease in salmonids downstream of the dam, no affected fish have ever been found (H. Smith, Environmental Planning, BCHPA, pers. comm., August 18, 1989).

As stated in the water quality section of this report, levels of cadmium and cyanide in the water exceed Federal Drinking Water Quality Guidelines for the Protection of Aquatic Life. However, their effects on fish populations in the river are not known at this time. In addition, it has been reported that toxicity of the effluent from the Celgar pulp treatment facilities could induce sublethal toxic effects in fish at river flows of less than 350 m^3/s (12,400 ft^3/s).

3.2.3 Wildlife Resources

Mica Reservoir

Habitat Conditions

At full pool, Mica Reservoir is over 200 km (124 mi) in north-south length and has a surface area of about 42,500 ha (104,975 acres). It lies in the Rocky Mountain Trench, a waterfowl migration route. Drawdown zone substrates, for the most part, are strongly sloping, support no vegetation, and are little used by wildlife. A few exceptions are discussed in later sections of this report. Typical of storage reservoirs in mountainous parts of B.C., reservoir levels rise rapidly in spring and early summer in response to alpine snowmelt, reaching full stage in July or August, then gradually fall through late summer, autumn, and winter to a seasonal low in March or April. This variable environment is unsuitable for most species of wildlife. The reservoir is usually ice-covered from January to April.

Wildlife Occurrence

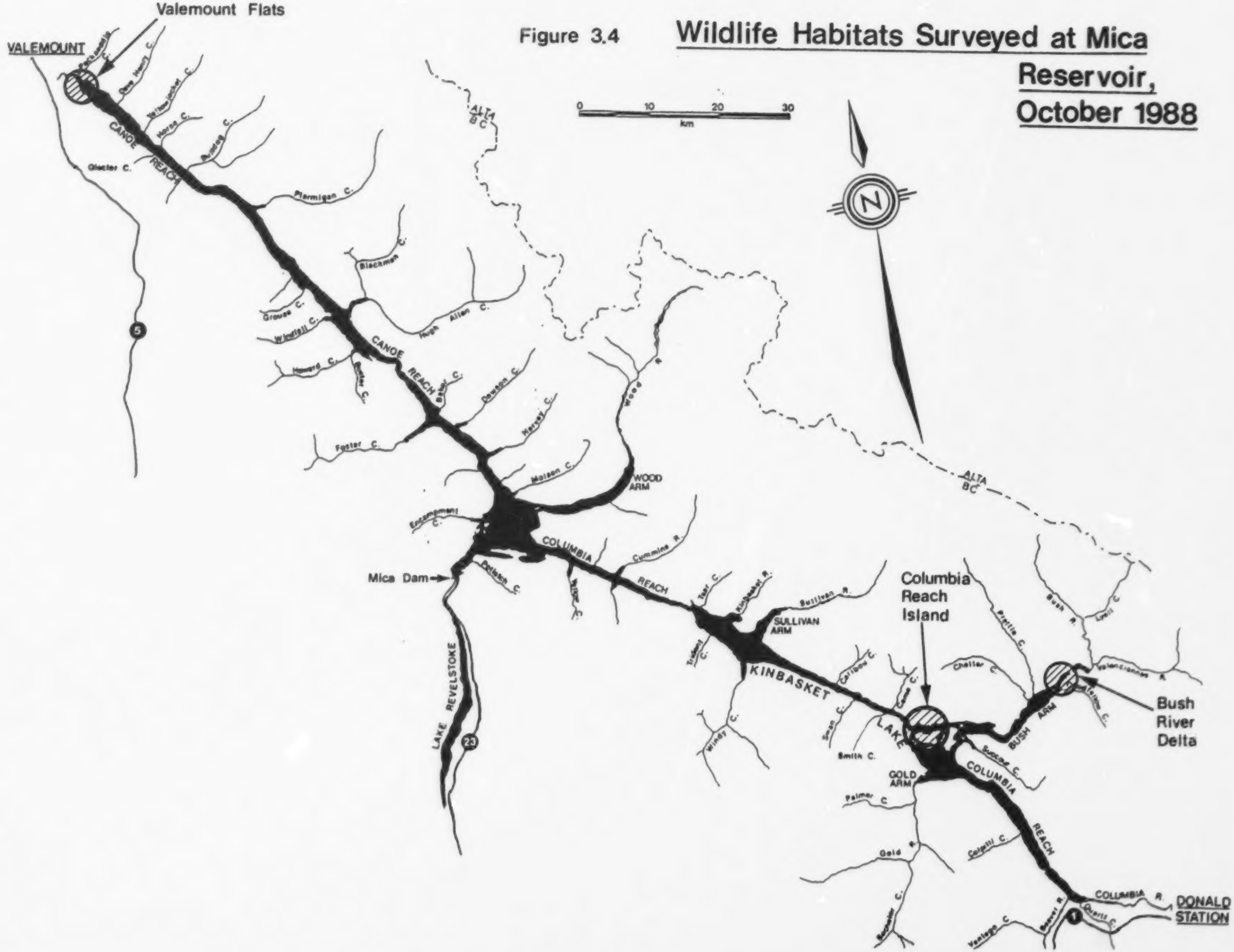
Little information is available on wildlife use of this reservoir. Pre-impoundment evaluations are sketchy (Peterson and Withler 1965a; E.L.U.C. 1974a) and provide little insight into post-impoundment conditions. Ministry of Environment staff have had little incentive to do post-flooding inventory work because most of the high quality wildlife habitat in the basin was flooded and because storage reservoirs are generally unattractive to wildlife .

A variety of terrestrial wildlife species occupy upland habitats above full pool (E.L.U.C. 1974a), but are not considered here because modification of the reservoir operational regime should have no effects on them. An exception could involve species like caribou which are reported to migrate seasonally across the reservoir.

Small numbers of waterfowl and shorebirds utilize the reservoir at certain seasons, however year-round surveys have not been conducted. A few bald eagles and ospreys nest around the shoreline. River otters are probably the only fur-bearing mammals associated directly with the reservoir. Beaver and muskrat inhabit some wetland areas adjacent to the reservoir. Fish-eating species such as bald eagles, ospreys, and bears are attracted to spawning runs of fish like kokanee in tributary streams.

A reconnaissance flight in August, 1988 identified three sites around the reservoir shoreline with potential significance as wildlife habitat (Figure 3.4). These sites were then visited on the ground in October, 1988 to assess autumn habitat conditions and use by wildlife.

Figure 3.4 Wildlife Habitats Surveyed at Mica Reservoir, October 1988


Valemount Flats
VALEMOUNT
0 10 20 30
km
ALTA
BC
CANOE REACH
Glacier C.
Camp Creek C.
Dave Henry C.
Yellowjacket C.
Horse C.
Bulldog C.
Ptarmigan C.
Blackman C.
Grouse C.
Windfall C.
Hugh Allan C.
Howard C.
Butler C.
Baker C.
Dawson C.
Harvey C.
Foster C.
Molson C.
Wood R.
WOOD ARM
Encampment C.
Mica Dam
Potlatch C.
COLUMBIA REACH
Cummins R.
Tsar C.
Kinbasket R.
Trident C.
SULLIVAN ARM
Sullivan R.
KINBASKET LAKE
Windy C.
Caribou C.
Sprague C.
Smith C.
Canoe C.
Columbia Reach Island
Prattle C.
Bush R.
Lyell C.
Chatter C.
Valenciennes R.
Bush River Delta
BUSH ARM
Succour C.
GOLD ARM
Palmer C.
Gold R.
COLUMBIA REACH
Colpitti C.
Bachelor C.
Ventego C.
Beaver R.
Quartz C.
COLUMBIA R.
DONALD STATION
LAKE REVELSTOKE
5
23
1

Appendix 2 lists the number of birds and mammals observed during the October 1988 survey.

Valemount Flats

Habitat Conditions

At the head of Canoe Reach, there are several hundred hectares of sparsely to densely vegetated flats west of the mouth of the Canoe River. This is the only significant area of gently sloping shoreline around Canoe Reach. Based on the driftwood line, some of the better vegetated habitat here is above full pool level, though within the area that was cleared of trees prior to flooding. Most of the bird observations on these flats were made at some small beaver ponds here. The flats were well exposed in early August, 1988. By October, 1988, the reservoir had dropped 1 to 2 m (3.3 to 6.6 ft) below the summer level, exposing barren mud/sand substrates below the vegetated zone.

The upper edge of the drawdown zone here (apparently seldom flooded) is dominated by grasses such as reedgrass (Calamagrostis sp.), and in some areas by foxtail (Alopecurus sp.). The slightly lower driftwood zone is dominated by horsetail (Equisetum sp.) on saturated organic soil. Sparse vegetation below the driftwood zone consists largely of sedges (Carex sp.), also growing on mucky organic soils. Seepage from upslope may be important in maintaining the horsetail and sedge stands, which were not flooded at all by the reservoir in 1988.

Wildlife Occurrence

The only significant wildlife use noted in this area in October 1988 was at an old beaver pond just above the maximum reservoir water level. All waterfowl sighted at Valemount Flats (Appendix 2) were at this pond. Below the driftwood line, moderate sign of goose grazing on sedges was noted and goose droppings were present but no geese were seen. Geese had probably been here in summer. No waterfowl of any kind were present on shallow waters at the mouth of Canoe River on October 18, 1988. A few open-country songbirds such as pipits and longspurs use these flats during migration. River otters are likely the only fur-bearing mammals associated directly with the reservoir. Otter sign was common at the reservoir edge, and one den was located in a hollow log. Beaver and muskrat inhabit some wetland areas adjacent to the reservoir.

More waterfowl could be present at times of peak migration, but these would probably move through the area quickly in view of the lack of marshy habitat.

Habitat Use in Relation to Reservoir Levels

The lack of seasonal wildlife inventory data and of detailed topographic mapping preclude any in-depth discussion of relationships between reservoir levels and wildlife use of local habitats. However, the lack of any significant standing water or marsh vegetation in the drawdown zone is a severe limitation at any season. One or two duck broods could be produced at the old beaver pond which is just above full pool, but any waterfowl nesting in the drawdown zone is unlikely. Water levels will always be well below the vegetated zone during spring migration, therefore essentially no use of these flats by spring migrants is expected. In years when the reservoir fills and then recedes so that some of the upper vegetated area is shallowly flooded in fall, some use by fall migrants could occur. However, this shallow flooding did not happen in 1988, probably accounting for the scarcity of birds here in October.

Columbia Reach Island

Habitat Conditions

A large mudflat is located between the unnamed island in Columbia Reach and the reservoir shoreline north of the island. On October 19, 1988, this mudflat was about 250 ha (618 acres) in size. Many stumps are present in the eastern part of the area. On the western side of the mudflat, stumps appear to have been bulldozed into piles and burned, leaving many low hummocks. These support some sparse terrestrial plant cover which was evidently not flooded in 1988. In mid-October 1988, a large sheltered lagoon was present in the central part of the mudflat, and small shallow ponds were scattered across it, within 1 m (3.3 ft) elevation of reservoir level. Most of the mudflat supports no vegetation, but some is present along its northern edge; primarily wetland species growing in moist sites among the stumps. This vegetation was probably not flooded in 1988. More extensive sedge-dominated wetlands and an old beaver pond occur at and above full pool at the north edge of the flats. These are contiguous with the muddy flat and partly within the area of tree clearing, but are probably never flooded.

Wildlife Occurrence

More waterfowl and their sign were seen here than at any other site around Mica Reservoir (Appendix 2). This was the only site at which a flock of ducks was seen during the August reconnaissance flight. In October, over 200 ducks were using the lagoon and adjacent flats, extensive goose sign was present on the vegetated hummocks, and migrating shorebirds were probing for food in the shallow ponds. The goose sign was not fresh, and was most likely attributable to molting birds. E.L.U.C. (1974a) refers to pre-impoundment use of sloughs and lakes in this area by molting geese, and this activity appears to have continued. The Canada goose molt occurs between mid-June and mid-July, i.e. at high water. Geese may occasionally nest in this area but it appears to be generally unsuitable for nesting. The same applies to dabbling ducks.

Habitat Use in Relation to Reservoir Levels

A shallow, sheltered lagoon and adjacent wet mudflats with shallow ponds at this site provided good resting habitat for waterfowl at reservoir levels prevailing on October 19, 1988. Ducks may find some food here in the form of invertebrates in the mud, but it does not appear to be a rich feeding area. At lower reservoir levels the mudflat would dry out and the lagoon would decrease in size or disappear, however additional mudflats might also be exposed. At slightly higher levels, the mudflats would be shallowly flooded and the small hummocks would form islands which, in autumn, would probably also be attractive to migrating waterfowl. During spring migration these flats would be dry, some distance from open water of the reservoir, and probably not used by migrating waterfowl. However, a variety of other sites may serve as rest stops during spring migration. Habitat conditions during spring migration in April through early May were not surveyed.

Bush River Delta

Habitat Conditions

This is a wide, braided delta of low gradient, between high mountains. The glacier-fed river has deposited extensive silt over sand and gravel substrates. The location of the delta front varies greatly from season to season as reservoir levels rise and fall. The delta front was about 1.5 km (0.9 mi) wide in October 1988. Because of the flatness of the valley bottom, the upper limit of flooding is difficult to determine.

In the area examined in October, between the delta front and logging road crossing, aquatic habitat consisted only of flowing channels of the Bush River; standing water bodies were absent. Sparse plant growth is encountered as one proceeds up the delta away from the October 1988 shoreline location. A few willow shrubs occur on higher sites near the logging road.

Wildlife Occurrence

The drawdown zone portion of this delta is quite barren, and little wildlife or wildlife sign was noted in October, 1988 (Appendix 2). The site has no waterfowl production capability, and probably receives little or no use by migrants. No waterfowl were seen at the delta itself on October 19, although some old Canada goose sign was present. Canada geese are expected to nest around wetlands and on islands in the Bush River above the influence of the reservoir, and may move downstream through the delta. Great blue heron tracks were common beside some river channels, and two herons were seen flying across the delta. Open-country songbirds like longspurs and horned larks occur on these flats during migration.

Moose, caribou, and deer tracks were all seen on the delta. In all cases these appeared to be crossing the delta and not attracted by the delta habitats themselves.

Habitat Use in Relation to Reservoir Levels

There is probably little wildlife use of the drawdown zone portion of this delta at any reservoir level. Alternate flooding and drying, plus wave action and silt deposition, make this a hostile environment for plant establishment. At low reservoir levels, even the sparse vegetation on this delta would be a considerable distance from the open waters of the reservoir. The small amount of goose sign seen here probably originated in summer when reservoir levels were fairly high.

Other Locations Around Mica Reservoir

Habitat Conditions

The majority of the drawdown zone outside of the locations discussed above is moderately to very steeply sloping and barren of vegetation. An exception with respect to steepness is the south end of the reservoir where the Columbia River enters. In early August, 1988, many sandbars were seen from the air in this area, but none appeared to support herbaceous vegetation. During the aerial reconnaissance, a few scattered sites along the reservoir near full pool were noted to support plant growth. The plant species involved and their use by wildlife are unknown.

Wildlife Occurrence

A few waterbirds such as loons, grebes, diving ducks, and gulls may be present anywhere on the reservoir surface during the open water period. Pairs of loons were seen in summer, and probably nest here. Little waterfowl use is expected outside of the areas previously described, although Canada geese may loaf on sandbars at the south end where a flock of 13 was seen in August 1988.

One bald eagle nest (Columbia Reach opposite Caribou Creek) and one osprey nest (Wood Arm) were seen from the air. Although additional nests are likely, the nesting density of ospreys appear to be much lower here than at the Arrow Lakes Reservoir. This is probably due to lower levels of fish production in Mica Reservoir than in the Arrow Lakes Reservoir (Section 3.2.2).

Black bears probably forage around the shoreline. One was seen swimming across Bush Arm in August, 1988. Ungulate movements across the reservoir are largely unknown, however E.L.U.C. (1974a) suggests that caribou migrate across the Columbia River in autumn near the mouths of the Sullivan and Bush Rivers. As noted, caribou tracks were observed on the Bush River delta in October 1988.

Habitat Use in Relation to Reservoir Levels

Wildlife use of drawdown zone habitats is generally low and the reservoir regime probably has little effect on use. An exception could involve the effect of reservoir level fluctuations on ice cover and configuration of the ice surface. Broken or strongly sloping ice sheets could impede cross-valley ungulate movement in winter, if such movement occurs. If caribou cross in autumn, as previously suggested, they could swim across narrow reaches of the reservoir with little difficulty.

Arrow Lakes Reservoir

Habitat Conditions

The Arrow Lakes Reservoir at full pool in July is about 200 km (124 mi) long and up to 3.75 km (2.3 mi) wide, with a surface area of 47,500 ha (117,325 acres). At normal maximum drawdown in March the surface area is reduced to about 36,500 ha (90,155 acres), and 11,000 ha (27,170 acres) of drawdown zone is exposed. Drawdown zone habitats vary from small rich perched marshes near full pool elevation to barren gravel, sand, silt or mud substrates at lower elevations. Vegetated habitats are largely between full pool elevation (440 m; 1444 ft) and the 435 m (1427 ft) level, where shorelines are flat to gently sloping and soils are fine-textured. Such conditions occur primarily in the extreme north end of the reservoir on the former floodplain of the Columbia River, and at scattered locations of gentle relief elsewhere around the reservoir perimeter, largely at stream deltas. Although some of the dominant plant species in the drawdown zone are known, studies of plant community composition and environmental relationships have not been carried out.

Wildlife Occurrence

The Arrow Lakes occupy a deep, narrow north-south oriented valley which, like the Okanagan and Kootenay Lake valleys and the Rocky Mountain Trench, forms a natural migration route for birds, especially waterfowl and other aquatic/wetland species.

Wildlife species of concern are primarily those which live on or in the water like waterbirds and aquatic furbearers or terrestrial species like ospreys which obtain their food from it. Significant wildlife species or groups at the Arrow Lakes Reservoir, and a summary of their seasonal occurrence, major habitats, and food habits, are provided in Table 3.7.

North End of Arrow Lakes Reservoir

Habitat Conditions

This habitat unit, referred to as "north-Arrow", extends from Revelstoke to Arrowhead (37.5 km (23.3 mi)) and has a total area at full pool of about 7000 ha (17,290 acres) (Figure 3.5). When reservoir levels drop to 424 m (1391 ft) the entire area is exposed except for the channels of the Columbia River and a few small perched basins near Revelstoke. Reservoir fluctuations result in an extremely variable environment for wildlife.

The reservoir bottom in this area, consisting primarily of the former floodplain of the Columbia River, is relatively flat in cross-section, and slopes to the south at a gradient of about 0.5 m/km (2.6 ft/mile). Substrate materials are primarily silt and sand over gravel. At full pool, maximum water depth in this area (at its southern extremity) is only 17 m (56 ft), and much of it is covered with only a few metres of water.

Complete drying of this area normally occurs in March and early April, followed by a rapid rise in level through May and June to a peak in mid-July. Levels usually drop gradually from August to March, resulting in gradual southward exposure of the reservoir bottom.

Plant growth in the north-Arrow drawdown zone is essentially limited to sites between the 435 m (1427 ft) level and full pool. Most of the vegetated habitat is on the east side of the reservoir, between Revelstoke and Drimmie Creek. It totals about 1300 ha (3211 acres) (Table 3.8). Reed canary grass (Phalaris arundinacea) and horsetail (Equisetum hyemale) are two of the most common plants in this area, the former at the upper limits of reservoir flooding, the latter at somewhat lower elevations. Various sedges, rushes and other plants also occur. Ryegrass (Elymus sp.) is planted each spring on 162 ha (400 acres) of flats

TABLE 3.7

Major Wildlife Groups Which Utilize the Arrow Lakes Reservoir

Species	Seasonal Occurrence	Major Habitats	Food Habits
A. BIRDS			
1. Canada Goose	1) Resident population - may vacate area in cold winters. Some nest around reservoir perimeter.	1) Shoreline around most of the reservoir. Major population at north end.	Graze on green vegetation around the shoreline, and in nearby farm fields.
	2) Migrant population - largely present in spring and fall.	2) Most stop at wetlands in north end of the reservoir.	
2. Dabbling Ducks	Most occur as spring and fall migrants. Small numbers of a few species nest around wetlands near Revelstoke.	Shallowly flooded wetlands, mostly at north end of reservoir.	These ducks primarily "dabble" (tip-up) to feed on aquatic plants, seeds, and benthic invertebrates in shallow water.
3. Diving waterbirds (Diving ducks, grebes, and loons)	Mainly spring and fall migrants. Some present in winter.	Open water of the reservoir. Some species (e.g. buffleheads) use wetlands at north end.	Planktonic and benthic invertebrates and small fish.
4. Marsh birds	Mainly summer residents (e.g. blackbirds; herons; coots; marsh wren)	Revelstoke Airport wetlands and Montana Slough.	Varied (insects, green matter, small fish, amphibians).
5. Shorebirds	Almost entirely in spring and fall migration.	Mudflats and shorelines.	Probe for seeds and/or invertebrates on wet or shallowly flooded mudflats.
6. Osprey	Summer	Nest in trees around entire reservoir and on powerline towers in some areas.	Feed on medium-sized fish throughout the reservoir.

TABLE 3.7 (continued)

Species	Seasonal Occurrence	Major Habitats	Food Habits
B. MAMMALS			
1. Muskrat/beaver	Year-round	Revelstoke Airport wetlands and Montana Slough.	Bullrush and pondweeds (both species); shoreline trees/shrubs (beaver).
2. River otter	Year-round	Throughout reservoir.	Fish; occasionally waterfowl.

Figure 3.5 **The North-Arrow Wildlife Survey Area, October 1988**

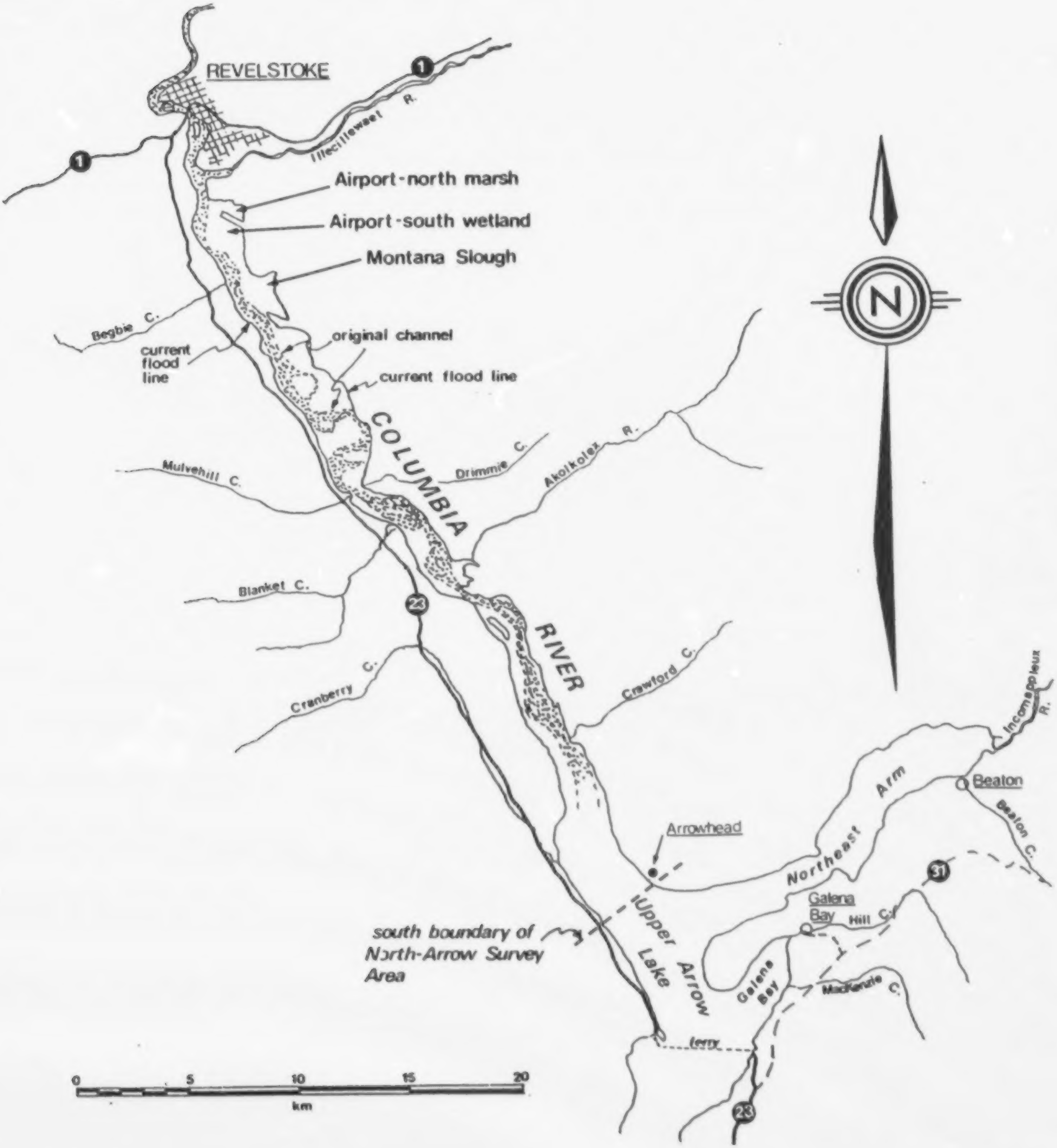

REVELSTOKE
1
1
Illecillewaet R.
Airport-north marsh
Airport-south wetland
Montana Slough
Begbie C.
current flood line
original channel
current flood line
COLUMBIA RIVER
Mulvehill C.
Drimmie C.
Akolkolex R.
Blanket C.
23
Cranberry C.
Crawford C.
N
Incomappleux R.
Beaton
Beaton C.
Northeast Arm
Arrowhead
31
Galena Bay
Hill C.
Upper Arrow Lake
south boundary of North-Arrow Survey Area
Galena Bay
MacKenzie C.
ferry
23
0
5
10
15
20
km

TABLE 3.8

Approximate Area of Various Vegetated Wetland Habitats in North-Arrow Drawdown Zone, Revelstoke to Drimmie Creek

Location	Habitat	Area (ha)[1]	Area (acres)
Airport north	Dense emergent vegetation	70	173
	Open water with pondweeds	25	62
	Sub-total	95	235
Airport south	Horsetail/canary grass stands	20	49
	Open water	5	12
	Sub-total	25	61
Montana Slough	Peripheral vegetation	12	30
	Open water	9	22
	Sub-total	21	52
From Airport south wetland to Drimmie Cr.	Moderately to sparsely vegetated flats with little or no standing water	1,150	2,842
TOTAL		1,291	3,190

[1] determined with dot grid on 1:20,000 colour aerial photos taken in August 1977.

south of Revelstoke airport to control wind-borne silt. Canada geese have been noted to graze on the ryegrass (A. Brotherston, Senior Environmental Coordinator, BCHPA, pers. comm., Dec. 16, 1988).

Density and productivity of vegetation vary tremendously from place to place within the north-Arrow drawdown zone. Upland plants are not generally able to establish in the drawdown zone because of intolerance to flooding, although a few annuals become temporarily established.

The Airport-north marsh is the only location in the entire Arrow Lakes drawdown zone supporting marsh/fen vegetation (Figure 3.5). Dense to open stands of emergent grasses and sedges are present, as well as small patches of cattail bulrush. Open water areas have a dense growth of submerged pondweeds in summer. These plants, plus the presence of muskrat houses, indicate that water levels are relatively stable. This marsh is about 95 ha (235 acres) in size, and probably receives more waterfowl use per unit area than any other site in the Arrow Lakes Valley.

Following spring snowmelt (May 2, 1985), the water level in this marsh was 439 m (1441 ft). When the reservoir is full this level is raised by about 1 m (3.3 ft). Air photos taken in August 1977, a drought year when the reservoir did not fill, show a much-reduced water area, with a probable level of 436 to 437 m (1430 to 1434 ft). Despite these variations the important factor for plant growth and wetland wildlife use is that the site does not dry out. Seepage from upslope, plus the damming effect of the runway probably aid in water retention when reservoir levels are low. In years when this marsh is flooded by the reservoir, levels are above the natural spring level for about 94 days per year, from approximately mid-July to late October (Table 3.9). Although this is a fairly lengthy period, levels are only raised by up to 1 m (3.3 ft), therefore the emergent vegetation stands are able to survive.

The Airport-south wetland, about 20 ha (49 acres) in extent, consists of standing water in borrow pits originating from runway construction, and dense stands of horsetail on adjacent mudflats (Figure 3.5). Water levels here fluctuate more than in the Airport-north marsh, but the borrow pits hold water year-round. The stands of horsetail appear to remain moist for most of the year. The most dense horsetail stands are at an elevation of about 436 to

TABLE 3.9

Timing and Duration of Flooding of the Airport Marsh and Montana Slough, 1970-1988

	Airport Marsh	Montana Slough
Wetland water level in spring[1]	439.3 m (1,411 ft)	437.7 m (1,436 ft)
Mean no. days flooded (above spring level)[2]		
- All years	79	121
- Years when flooded[3]	100	136
Maximum no. of days above spring level[2]	187 (1981)	214 (1981)
Date reservoir rose to the spring level[2]		
- Earliest	June 2	May 25
- Median	July 8	July 3
- Latest	Aug. 10	July 25
Date reservoir fell to the spring level[2]		
- Earliest	Aug. 3	Aug. 5
- Median	Oct. 31	Dec. 6
- Latest	Dec. 21	Jan. 1

[1] levels on May 2, 1985 (BCHPA data)

[2] determined from graphs of Arrow Reservoir levels (provided by BCHPA)

[3] 15 out of 19 years for the Airport Marsh; 16 out of 18 years for Montana Slough

437 m (1430 to 1434 ft), while canary grass is dominant in the 437 to 438 m (1434 to 1437 ft) range. There is little or no vegetation in the standing water.

Montana Slough, to the south of the airport sloughs (Figure 3.5), also holds water when reservoir levels drop but has not developed marsh vegetation to the same extent as the Airport-north marsh. It is at a slightly lower elevation (Table 3.9) and is therefore flooded too deeply and for too many days to allow emergent marsh species to develop. Other factors such as soil type may also be involved. Montana Slough is about 20 ha (49 acres) in size.

Standing water in the three wetlands described above are ice-covered and are not used by waterfowl in winter. In spring they provide almost the only standing water between Arrowhead and Revelstoke.

Plant growth in the north-Arrow area, outside of the areas mentioned above, is highly variable in density and distribution. Best growth is on sites which, due to topographic and soil conditions or seepage from upslope, remain moist when exposed through reservoir drawdown. Much of this large area is sparsely vegetated (Table 3.8).

As noted previously, conditions for plant establishment and growth in the upper drawdown zone are highly variable, as illustrated by the following data on flooding at the 439 m (1440 ft) elevation:

Year	Period Flooded	Flooding Duration	Maximum Depth
1977	not flooded	nil	N/A
1978	July 7 - Oct. 31	16.5 weeks	1.5 m (4.9 ft)
1979	not flooded	nil	N/A
1980	June 23 - Aug. 20 Sept. 24 - Nov. 26	17.3 weeks	1.5 m (4.9 ft)
1981	June 3 - Nov. 15	23.6 weeks	1.8 m (5.9 ft)

Despite the variable flooding regime, some vegetation used by wildlife has developed and appears to be persisting in fairly extensive areas of the north-Arrow drawdown zone.

Wildlife Occurrence

Considerable waterfowl survey information is available for the north-Arrow area, particularly the Revelstoke Airport wetlands and Montana Slough. Seven hundred and eighty one individual surveys were done here from 1977 to 1984, presumably to provide input to possible enhancement projects which might compensate for Revelstoke Reservoir wildlife impacts. Survey results through 1982 were reported in draft form by Bonar (1982).

Species Composition

Table 3.10 provides a general indication of species composition of aquatic birds in this area, based on counts done at all seasons of the year. Of 36 species listed, Canada geese are the most common, followed by mallards, coots, American wigeons, pintails, and green-winged teal. Those six species comprise 84% of all aquatic birds counted. Two species, the adaptable and early-nesting Canada goose and the mallard, occur both as migrants and summer residents. Together they comprise 64% of all sightings.

Seasonal Occurrence

Surveys in the north-Arrow area indicate that most water birds using this area are spring and fall migrants (Table 3.11). Peaks of about 3000 birds occur in both spring and fall. Largest numbers of Canada geese occur in autumn (Table 3.12).

The spring waterfowl migration is relatively short, with peaks over the 1977-1981 period varying from April 7 to April 24 in relation to spring phenology. Fall migration peaks are usually in late September or early October, however the fall migration period lasts from late August to late November. During both migration periods the birds use habitats here for feeding and resting. Species composition during migration periods is expected to be similar to that indicated in Table 3.10. Birds observed in the north-Arrow area in October 1988 are listed in Appendix 3.1. In October 1988, three groups (Canada geese, dabbling ducks, and coots) made up 98% of all aquatic birds seen.

Smaller numbers of birds are present in summer. These are largely, but not entirely,

TABLE 3.10

Species Composition of Water Birds Using the North End of Arrow Lakes Reservoir, 1977-1984[1]

	Mean number counted per survey[2]	% of total counted
Loons		
Common Loon	tr.	
Grebes		
Horned	0.3	
Eared	0.5	
Pied-billed[3]	0.8	
Red-necked	1.1	
Western	3.9	
	6.6	0.9
Swans		
Trumpeter	tr.	
Unidentified	0.9	
Tundra	3.0	
	3.9	0.5
Geese		
White-fronted	tr.	
Snow	0.1	
Canada[3]	271.6	
	271.7	37.9

TABLE 3.10 (continued)

	Mean number counted per survey[2]	% of total counted
Mergansers		
Red-breasted	tr.	
Hooded	1.0	
Common[3]	9.1	
	10.1	1.4
Diving Ducks		
Harlequin	tr.	
Oldsquaw	tr.	
White-winged scoter	0.3	
Canvasback	0.4	
Ruddy Duck	0.6	
Redhead	0.7	
Surf scoter	2.6	
Goldeneye[3] sp.	7.8	
Scaup spp.	8.7	
Ring-necked duck	12.0	
Bufflehead	12.7	
	45.8	6.4
Dabbling Ducks		
Eurasian wigeon	tr.	
Gadwall	0.2	
Wood duck[3]	0.5	
Northern shoveller	2.0	
Cinnamon teal[3]	2.7	
Blue-winged teal[3]	5.9	
Green-winged teal	23.7	
Pintail	25.8	
American wigeon[3]	40.5	
Mallard[3]	186.7	
	323.0	45.0

TABLE 3.10 (continued)

	Mean number counted per survey[2]	% of total counted
Coots		
American coot	56.3	7.8
TOTAL	**717.4**	**99.9**

1 Data provided by Dr. R. Bradley, BCHPA

2 Based on 781 surveys carried out in all seasons of the year.

3 species known to breed in the area

tr. = <0.1 bird/count

TABLE 3.11

Seasonal Occurrence of Waterfowl in the North Arrow Area, 1977 through 1984[1]

Survey Period	Mean Count During this Period	Peak Migration Period	Maximum Count
Spring (20 March - 31 May)	758	Apr. 7-24	5,074
Summer (1 June - 14 Aug.)	250	N/A	1,014
Fall (15 Aug. - 15 Nov.)	1,000	Sept. 20-30	6,475
Early Winter[2] (16 Nov. - 31 Dec.)	962		5,211
Late Winter[3] (1 Jul. - 19 Mar)	178		819

[1] information provided by Dr. R. Bradley, BCHPA

[2] data for 1980, 1982, and 1983 only

[3] data for 1980 through 1984 only

TABLE 3.12

Approximate Maximum Counts of Canada Geese in the North-Arrow Area at Various Seasons

Period of Year	Maximum Count	Remarks
Spring Migration	300±	Daily counts of migrants flying past Revelstoke[1]
Spring Migration	2,917	Maximum count on wetlands in Revelstoke Airport area[3]
Summer Migration	770	Highest daily count in Revelstoke area[3]
Summer Resident	300±	Revelstoke Airport area in August[2]
Summer Resident	550	Entire north-Arrow area in August[2]
Fall Migration	6,475	Highest count in Revelstoke Airport-Montana Slough area[3]
Winter	5,211	North-Arrow area, winter 1983-1984[3]

[1] From Bonar (1982)

[2] Based on reconnaissance, August 1988

[3] Data provided by Dr. R. Bradley, BCHPA

individuals which nest in the area. Some non-breeders, especially sub-adult Canada geese, also utilize the area. Some indication of relative summer use of this area is given by cumulative 1977-1981 nest and brood observations reported by Bonar (1982) for the Revelstoke Airport Marshes-Montana Slough area, as follows:

Canada goose - 45 nests
Mallard - 17 broods
Blue-winged/cinnamon teal - 12 broods
Green-winged teal - 6 broods
Goldeneye sp. - 2 broods
American Wigeon - 1 brood
Wood duck - 1 brood
Common merganser - 1 brood
Pied-billed grebe - 1

The above is not an estimation of total production, since many nests or broods are never seen. However, it indicates that the adaptable, early- nesting Canada goose and mallard are the most common breeding species, and that the later nesting teal can also be successful at fairly stable sites like the marsh north of the airstrip.

Habitat Use in Relation to Reservoir Levels

When the earliest spring migrants arrive in March, reservoir levels are at their lowest. At the peak of spring migration they are still low, though starting to rise in some years. Because of low levels in spring, virtually all waterfowl use is at wetlands like the Airport Marsh and Montana Slough, or on wet mudflats in the upper drawdown zone. A few birds may loaf on sandbars along the Columbia River in spring. Because almost all migrant waterfowl use habitats above the prevailing reservoir level in spring, historical between-year variations in level at this season, e.g. <425 to +431 m (<1394 to +1414 ft) at peak migration, have probably not influenced waterfowl occurrence or habitat selection from year to year.

In the waterfowl nesting season water levels are normally rising. This co-occurrence of alpine snow-melt and waterfowl breeding can result in nest flooding, and is a limiting factor for waterfowl production in many valleys of interior B.C. Some waterfowl species here cope with this situation by nesting early and/or by nesting above full pool elevation around the Airport Marsh areas and Montana Slough. Water levels in those two wetlands do not rise until the reservoir reaches 438 to 439 m (1437 to 1440 ft), usually between early June and mid-July (Table 3.9). Variable timing of the spring flood from year to year results in an unreliable environment for waterfowl nesting. For example, in recent years the 437 m (1434 ft) level was reached anywhere from May 25 to July 8, a span of 44 days.

Reservoir elevations have historically been quite variable at time of peak fall migration, i.e. from about 426 to 440 m (1398 to 1444 ft). In most years levels are high (437 to 440 m (1434 to 1444 ft)) and gradually falling. Much of the vegetated area is still flooded at this time, offering a variety of waterfowl feeding sites in addition to the Airport Marsh areas and Montana Slough. These areas gradually dry in the later part of the fall migration.

Habitat use in relation to reservoir levels is summarized below for key wildlife species groups.

Canada Geese

The Canada goose is the most abundant single species in the north-Arrow area (Table 3.10). Both migrant and resident birds utilize habitats here, although even the "resident" birds often vacate the area in mid-winter. Such temporary winter movements are probably to more southern locations along the Arrow Lakes Reservoir. From spring to fall the resident birds also move about considerably within the north-Arrow area in response to seasonal habitat needs and variations in reservoir level. Numbers counted at various seasons are given in Table 3.12.

Water levels can vary considerably during goose migration periods (Table 3.13), but such variations probably have little effect on numbers of geese and no effect on survival. Water levels have been fairly high, though variable, during fall migration, resulting in a variable amount of shallowly flooded land available for feeding. This may cause variations in local distribution of migrant geese, and in the amount of time spent in the north-Arrow area.

Canada geese nest primarily around the Airport Marsh areas and Montana Slough. Water levels at those wetlands do not rise until after June 1 in most years (Table 3.9). By this time almost all geese have hatched. Bonar (1982) noted that one nest was flooded just prior to scheduled hatch in 1981, a year when the Arrow Reservoir reached full pool earlier than usual.

TABLE 3.13

Seasonal Occurrence and Activities of Canada Geese in the North-Arrow Area in Relation to Reservoir Levels[1]

Goose Activity	Timing of Activity	Reservoir Levels	
		Range (m)	Direction
Resident Geese			
a) Spring arrival	Feb. 17-March 27	425-430 (1394-1411 ft)	variable
b) Nest site selection and nest building	March 20-April 15	425-430 (1394-1411 ft)	starting to rise
c) Laying	March 31-April 18	425-431 (1394-1414 ft)	starting to rise
d) Incubation	March 31-June 13	425-440 (1394-1444 ft)	rising
e) Hatching			
- range	May 6-June 13	426-440 (1398-1444 ft)	rising
- peak	May 10-20	427-436 (1401-1430 ft)	rising
f) Flightless period	June 10-July 12	427-440 (1401-1444 ft)	rising
g) Late summer staging	July 10-Aug. 15	428-440 (1404-1444 ft)	falling

TABLE 3.13 (continued)

Goose Activity	Timing of Activity	Reservoir Levels Range (m)	Reservoir Levels Direction
Migrant Geese			
a) Spring migration			
- range	March 26-April 13	425-431 (1394-1414 ft)	starting to rise
- peak	April 1-6	425-430 (1394-1411 ft)	low and stable
b) Molt migration			
- range	May 19-June 8	426-439 (1398-1440 ft)	rising
- peak	May 27-June 1	426-438 (1398-1437 ft)	rising
c) Fall migration			
- range	Sept. 10-Oct. 16+	426-440 (1398-1444 ft)	falling
- peak	Sept. 18-Oct. 5	426-440 (1398-1444 ft)	falling

1 Compiled from information in Bonar (1982) and reservoir level data from BCHPA.

The relationship between availability of green vegetation and reservoir level is important to Canada goose utilization of the area, especially by the resident population. It seems likely that increased depth and duration of flooding would have a negative effect on Canada goose forage resources, however extreme drying of soils in years when the reservoir does not reach the vegetated zone could also be harmful. The species of plants involved and their relationship to reservoir levels are subjects requiring more study.

Dabbling Ducks

Dabbling ducks occur primarily as migrants and, as in the case of Canada geese, variations in reservoir level probably have little effect on their utilization of this area. Since these species, except wigeon, do not normally graze on the mudflats, most use during both migration and nesting periods is at the Airport Marsh areas and Montana Slough. All of the dabblers which nest here, except the wood duck, conceal their nests in dense upland cover of one kind or another. Wood ducks nest in tree cavities or nest boxes.

Dabbling ducks nest in dense grass or brush at varying heights above, and distances from, wetlands they have selected as brood-rearing sites. Mallards nest quite early and, like Canada geese, would not be flooded in most years. Blue-winged and cinnamon teal do not initiate nesting until late-May or June, and their peak of hatching is from about June 25 to July 20 (Bellrose 1976). Based on 1970-1988 data, this would preclude or seriously affect nesting by these species in many years. All of 18 teal broods observed by Bonar (1982) were recorded in 1977 and 1979, two years when the reservoir did not completely fill, which supports the suggestion that the summer flood limits production of most dabbling ducks in this area.

The effect of reservoir flooding on food resources of ducks resident in the breeding season is not clear. Most such food in the form of benthic invertebrates and aquatic plants is obtained at the Airport Marsh areas and Montana Slough. These sites appear to be little influenced by the reservoir at present. However, increased duration of flooding by cold reservoir waters could decrease the productivity of those wetlands.

Coots

Coots arrive in this area in April, and depart in late October. Up to 200 may be present in summer. Most use the Airport- north marsh with smaller numbers south of the airstrip and at Montana Slough. Coots build floating nests in shallowly-flooded emergent plant cover. These will usually rise if water levels increase, therefore nesting success of coots is not affected by flooding to the same degree as is that of dabbling ducks.

Muskrats

Muskrat houses were only noted at the Airport-north marsh. A few could occur elsewhere in the north-Arrow area, such as in bank dens along stream channels in the upper part of the drawdown zone.

Muskrats are fairly tolerant of summer flooding, although females with new litters may be disrupted. However, most litters in interior B.C. are born before mid-July (Blood 1988). Pregnant females often resort to bank dens if houses in marshes are flooded. Stable water levels are needed for muskrat survival over winter so that the rats can continue to use their houses and push-ups and can travel under the ice in search of food. Water levels in the Airport-north marsh probably drop naturally during winter, but not enough to preclude muskrat survival. Winter reservoir levels in recent years should have had no influence on muskrat survival at the Airport marsh.

Arrow Lake Narrows

The Narrows proper are about 15 km (9.3 mi) in north-south extent, from approximately the mouth of Slewiskin Creek to Sand Island. However, wildlife surveys here include a larger area, from Nakusp in the north to Edgewood in the south. Reservoir width in the Narrows area varies greatly according to seasonal stage.

Habitat Conditions

The Narrows area provides somewhat better wildlife habitat than elsewhere around the reservoir (except for the north-Arrow area) largely because of its gently sloping shorelines.

However, there is little or no habitat like the Revelstoke airport marshes. In mid-October, 1988, habitat in this area consisted of scattered mud, sand, and gravel flats, largely in the Narrows proper. These are associated with areas of low relief, such as around East Arrow Park. Moist, gently sloping sites also occur at creek deltas such as at Burton and Edgewood. Little of this could be called wetland habitat. In some areas, dense stands of reed canary grass occur at and immediately above the driftwood zone, but this community appears to be of little importance to wildlife. The part of the drawdown zone of most significance here is a usually narrow band between the tall grass fringe and barren gravel/sand zone which supports sparse, low grass/forb growth.

Wildlife Occurrence

Aquatic birds are the most common species here. Ospreys nest in trees along the shoreline. Otters are the only mammals frequenting the drawdown zone and reservoir waters. Birds observed in the Nakusp to Edgewood area in mid-October, 1988, are listed in Appendix 3.2. The Canada goose was the most common species (although most were grazing on farmland several kilometres from the shoreline), followed by dabbling ducks (mostly mallards), grebes, and loons. Most of the geese and mallards in this area were probably counted, however birds on the reservoir surface (loons; grebes; diving ducks; gulls) were counted at only a few places having convenient access. Actual numbers of those birds in this area may have been substantially higher than given in Appendix 3.2.

Seasonal abundance of waterbirds here is not known because counts have not been made during other seasons. Highest numbers are expected during spring and fall migration, but species like loons and grebes may be common through the winter. During a reconnaissance flight on August 4, 1988, 222 Canada geese were counted in this area. No attempt was made to count other species of birds, however very few ducks appeared to be present in August.

Thirteen osprey nests were counted in this area in August 1988. No ospreys were seen in late October.

Otter tracks were observed mostly in muddy areas immediately adjacent to reservoir waters, especially at stream deltas. These animals occur here year-round.

Habitat Use in Relation to Reservoir Levels

Canada Geese

Canada geese probably inhabit this area year-round through a wide range of water levels. Grazing habitat is mostly in the upper 5 to 10 m (16 to 33 ft) zone which is flooded for a relatively short period. Farm fields are also used, even when reservoir levels drop. It is unlikely that many geese nest in this area, but these birds are adaptable and a few might nest along the lower reaches of larger tributary streams and take their hatched broods onto the reservoir. Some geese in the Kootenay area also nest in osprey nests (Blood 1982) and could do so here. A few may nest in dense grass stands which are at about full pond. These appear to be at high enough elevations to preclude being flooded before hatching.

Dabbling Ducks

Dabbling duck use of habitats here probably involve relatively small numbers of birds, primarily during migration, and mostly for loafing. Adequate habitat for such use is probably available over a wide range of reservoir levels, and year-to-year variations in level probably have little effect on dabbling duck abundance in this area.

Diving Birds

Diving birds primarily use this area for feeding on fish, plankton, or benthic invertebrates. The areal extent of habitat available to these birds is decreased when reservoir levels drop, however food resources may become more concentrated. Variations in level at the same season in different years probably have little effect on overall use of the area by diving birds.

A few islands may exist temporarily at certain water levels, e.g. in Arrow Park Arm, and provide nesting sites for common loons. Further investigation would be needed to assess the current nesting success of loons and its relationship to reservoir levels.

TABLE 3.14

Aquatic Birds Counted Between Hugh Keenleyside Dam and Arrow Park, South End of Arrow Lakes Reservoir[1]

		Number of Birds			% of
Species	May 30	Oct. 10	Mar. 26	Total	Total
Loons				0	
Grebes					
Red-necked	2			2	
Horned			32	32	
Eared		2		2	
Western		28		28	
				64	19.8
Dabbling Ducks					
Mallard	1	71	8	80	
Pintail			5	5	
Blue-winged teal	20			20	
American wigeon		13	18	31	
				136	42
Diving Ducks					
Scaup sp.		6		6	
Comm. goldeneye			11	11	
Bufflehead		12	8	20	
White-winged scoter			10	10	
Unidentified		6	3	9	
				56	17.3
Mergansers					
Common	6	10	15	31	9.6
Gulls					
Ring-billed		1		1	
Unidentified	1	33	2	36	
	–	—	—	37	11.4
TOTAL	30	182	112	324	100

[1] Aerial surveys carried out by Beak (1981)

Other Locations at Arrow Lakes

Habitat Conditions

Most of the Arrow Reservoir shoreline, outside of the north-Arrow and Narrows areas, is moderately to strongly sloping and supports little or no vegetation in the drawdown zone. A few isolated areas of more gentle relief occur, largely at stream deltas. These include the Incomappleux River, Halfway Creek, and Dog Creek (Renata) deltas. Historical reservoir fluctuations were described earlier.

Wildlife Occurrence

A few dabbling ducks and Canada geese occur at various stream deltas. Diving waterbirds are scattered over most of the reservoir surface at all seasons. The only systematic counts of aquatic birds on the reservoir in the south end of Lower Arrow Lake between Deer Park and Hugh Keenleyside Dam were conducted by Beak (1981) (Table 3.14). Results of the May 30 survey, well after spring migration, suggest that aquatic bird numbers are lower in summer than at other seasons. Bird numbers on the reservoir may be highest in fall, but no spring information is available. The March 26 count, carried out prior to arrival of most spring migrants, suggests that substantial numbers of birds may be present in winter. The area covered by the Beak surveys, about 4000 ha (9880 acres) or 10% of the reservoir area at full pool, suggests that 300 to 2,000 aquatic birds may be seasonally present on the reservoir, excluding the north-Arrow area.

During a reconnaissance fixed-wing flight over the reservoir on August 5, 1988, 37 osprey nests were counted in trees at or near the shoreline or on transmission line towers. It is probable that not all of these were active at the time, but also probable that many nests were missed as the flight path was not always optimal for survey of osprey nests. Nevertheless, this is one of the major osprey populations in B.C. Beebe (1974) has noted that in favoured areas, osprey nests may occur at intervals of 1 to 2 km (0.6 to 1.2 miles), and that "the flooding of major areas ... by hydroelectric dams has created significant areas of new habitat that seem quite suitable for ospreys". Based on data for the East Kootenay area, ospreys arrive in the southern interior during late April and early May and depart in late September and early October (Blood 1982). Feeding is almost entirely on fish. While food habit studies have not been carried out at Arrow Lakes Reservoir, kokanee are likely the major prey, based on their abundance in near- surface waters in summer (Section 3.2.2).

Habitat Use in Relation to Reservoir Levels

Comments made earlier regarding waterfowl (Canada geese; dabbling ducks; diving birds) essentially apply to the remainder of the reservoir.

Ospreys arrive when reservoir levels are rising and nest during the high water period. Nesting sites are not influenced by reservoir levels. Historical year-to-year variations in summer reservoir levels are not likely to have influenced the availability of fish on which ospreys prey.

Downstream Area

Habitat Conditions

This reach of the Columbia River, about 58 km (36 mi) long, is free-flowing but regulated, with a mean flow at Hugh Keenleyside Dam of about 1130 m^3/s (40,000 ft^3/s). Regulation has reduced the spring freshet, resulting in a low to high flow ratio of only 1 to 3, which has resulted in relatively stable habitat conditions for aquatic/riparian wildlife. The river does not freeze in winter. It is well entrenched, not very sinuous, and has few back channels or islands, therefore riparian habitats are of limited extent (Envirocon 1986). Some plant growth is known to occur on river bars and shorelines. Plant growth was not examined in detail for this study.

Wildlife Occurrence

Some wildlife information is available for the northern two-thirds of this reach (Beak 1981). Triton made a reconnaissance flight along the river in August, 1988.

Surveys between Oasis and Hugh Keenleyside Dam (Table 3.15) indicate that relatively small numbers of birds are present on the river. These are primarily migrants and

TABLE 3.15

Aquatic Birds Counted Along the Columbia River, Hugh Keenleyside Dam to Oasis[1]

	Number of Birds				
Species	May 30	Oct. 10	Mar. 26	Total	% of Total
Grebes					
Western	1	3		4	0.5
Geese					
Canada goose	11		6	17	2
Dabbling Ducks					
Mallard	54	121	27	202	
Blue-winged teal	44			44	
American wigeon		6	12	18	
Northern shoveler	2			2	
				266	31.1
Diving Ducks					
Ring-necked	1			1	
Canvasback	5			5	
Scaup sp.		2	5	7	
Common goldeneye			39	39	
Barrow's goldeneye	8		28	36	
Bufflehead			38	38	
White-winged scoter	2			2	
				128	15
Mergansers					
Hooded		2		2	
Common	91	25	72	188	
Red-breasted			1	1	
				191	22.3

TABLE 3.15 (continued)

Species	Number of Birds May 30	 Oct. 10	 Mar. 26	Total	% of Total
Gulls					
California		3		3	
Bonaparte's	5			5	
Unidentified	31	65	45	141	
				149	17.4
Shorebirds					
Killdear	7	12		19	
Spotted sandpiper	82			82	
	–	–	–	101	12
TOTAL	344	239	273	856	100

1 Aerial surveys carried out by Beak (1981)

wintering birds. Most abundant species are the mallard, blue-winged teal, goldeneye, bufflehead, common merganser, spotted sandpiper, and gulls. According to Beak (1981) the Columbia River is generally unsuited for waterfowl feeding, except for mergansers and some ducks like goldeneye, therefore most waterfowl are transients and "no more than a few thousand individuals pass through each spring and fall...". Common mergansers, mallards, and spotted sandpipers nest along the river, but production levels are low. Canada geese have not been reported to nest or rear broods along the river.

At least four pairs of ospreys nest along the river. No bald eagle nests are known here, but this species is relatively common in winter.

Despite regulation of river flows, this reach is considered to be poor beaver habitat, with probably no more than 10 animals present. A few otters, mink, and raccoon occur (Beak 1981), but the river is not an important area for trapping.

Habitat Use in Relation to Flows

Duck nesting here appears to be limited by lack of productive feeding habitat rather than nest flooding. Common mergansers, the most successful nesting species here, nest in tree cavities which would not be influenced by flow variations. A few mallards may nest around the Castlegar sewage lagoons and then take their broods onto the river. Spotted sandpipers nest in low herbaceous vegetation on gravel bars and islands. Under regulated conditions, this habitat is normally just above the highest river level.

Present variations in flow probably do not have much effect on the ability of fish-eating birds (osprey; mergansers) to locate prey. As noted in Section 3.2.2, fish are abundant in this stretch of the river. The fish species eaten by these birds in this area are not known.

3.3 Cultural Environment

3.3.1 Heritage Resources

Mica Reservoir

Although heritage surveys were not conducted prior to the creation of Mica Reservoir, one prehistoric site (E1 QM1), containing a flaked scraper, has been identified by the Archaeological and Outdoor Recreation Division of the Resource Management Branch of Municipal Affairs. The site is located on the west side of the reservoir at about El. 701 m (2300 ft) and was inundated at the time of flooding (Figure 3.6). It has also been damaged by logging activity in the vicinity. It is likely that other unrecorded heritage sites exist in the reservoir area.

As previously noted, the historic site of Boat Encampment located east of the Mica Dam was used as an overwintering area by David Thompson during his exploration of the Columbia River to its mouth (Figure 3.6). The site is presently under water. However, B.C. Hydro in cooperation with the Canadian Parks Service (formerly Parks Canada) has erected a Historic Site plaque nearby commemorating the visit.

Arrow Lakes Reservoir

Sites identified on the Arrow Lakes prior to flooding are indicated on Figures 3.7 and 3.8. In 1961, a three-month survey of the proposed pondage of the Arrow Lakes Reservoir was undertaken by the Archaeological Sites Advisory Board (Sigma Resource Consultants Ltd. 1975). The survey was intended to locate sites, assess their condition and recommend intensive excavations where warranted. The survey located a total of 77 sites, 49 on the Lower Arrow Lake, 18 on the Upper Arrow Lake and 10 on the Narrows between the lakes. Archaeological excavations were undertaken between 1966 and 1969 to salvage the prehistoric artifacts which would be inundated or damaged by construction of the reservoir. The major sites excavated include:

	Elevation
DiQm 1 - Cayuse Creek	421 m (1381 ft)

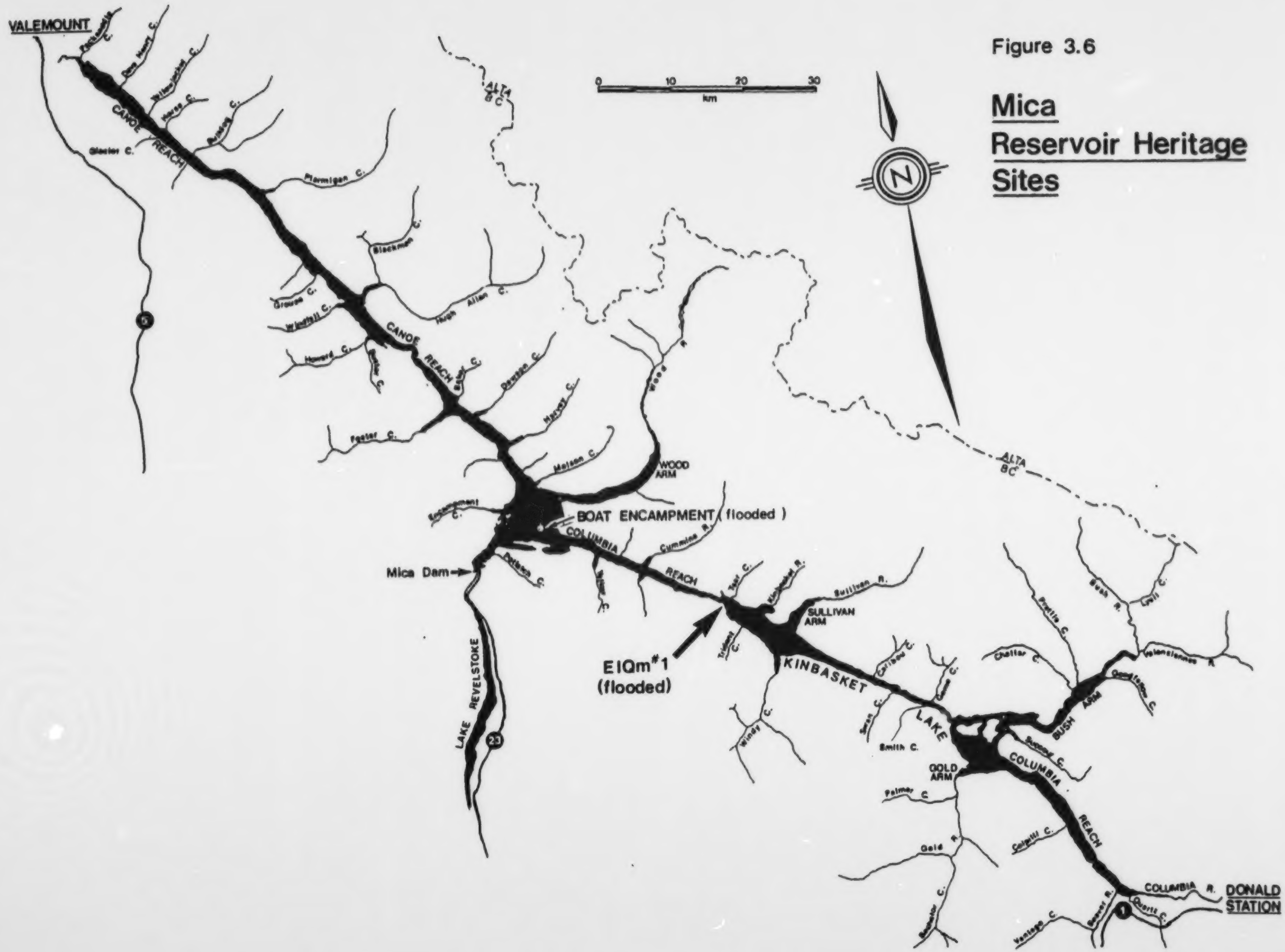

VALEMOUNT
Packsaddle C.
Dave Henry C.
Yellowjacket C.
Horse C.
Bulldog C.
Glacier C.
CANOE REACH
Ptarmigan C.
Blackman C.
Grouse C.
Windfall C.
Hugh Allen C.
Howard C.
Butler C.
Bulmer C.
Dawson C.
Harvey C.
Foster C.
Molson C.
Wood R.
WOOD ARM
ALTA BC
0 10 20 30
km
N
Encampment C.
BOAT ENCAMPMENT (flooded)
COLUMBIA REACH
Cummins R.
Mica Dam
Potlatch C.
Yellow C.
LAKE REVELSTOKE
23
5
Teal C.
Kinbasket R.
Sullivan R.
SULLIVAN ARM
Trident C.
EIQm#1
(flooded)
KINBASKET LAKE
Windy C.
Caribou C.
Swan C.
Smith C.
Prattle C.
Chatter C.
Bush R.
Lyell C.
Valenciennes R.
Goodfellow C.
BUSH ARM
Sprague C.
GOLD ARM
Palmer C.
Gold R.
Colpitt C.
COLUMBIA REACH
COLUMBIA R.
Beaver R.
Quartz C.
Vantage C.
Bachelor C.
1
DONALD STATION

Figure 3.6

Mica Reservoir Heritage Sites

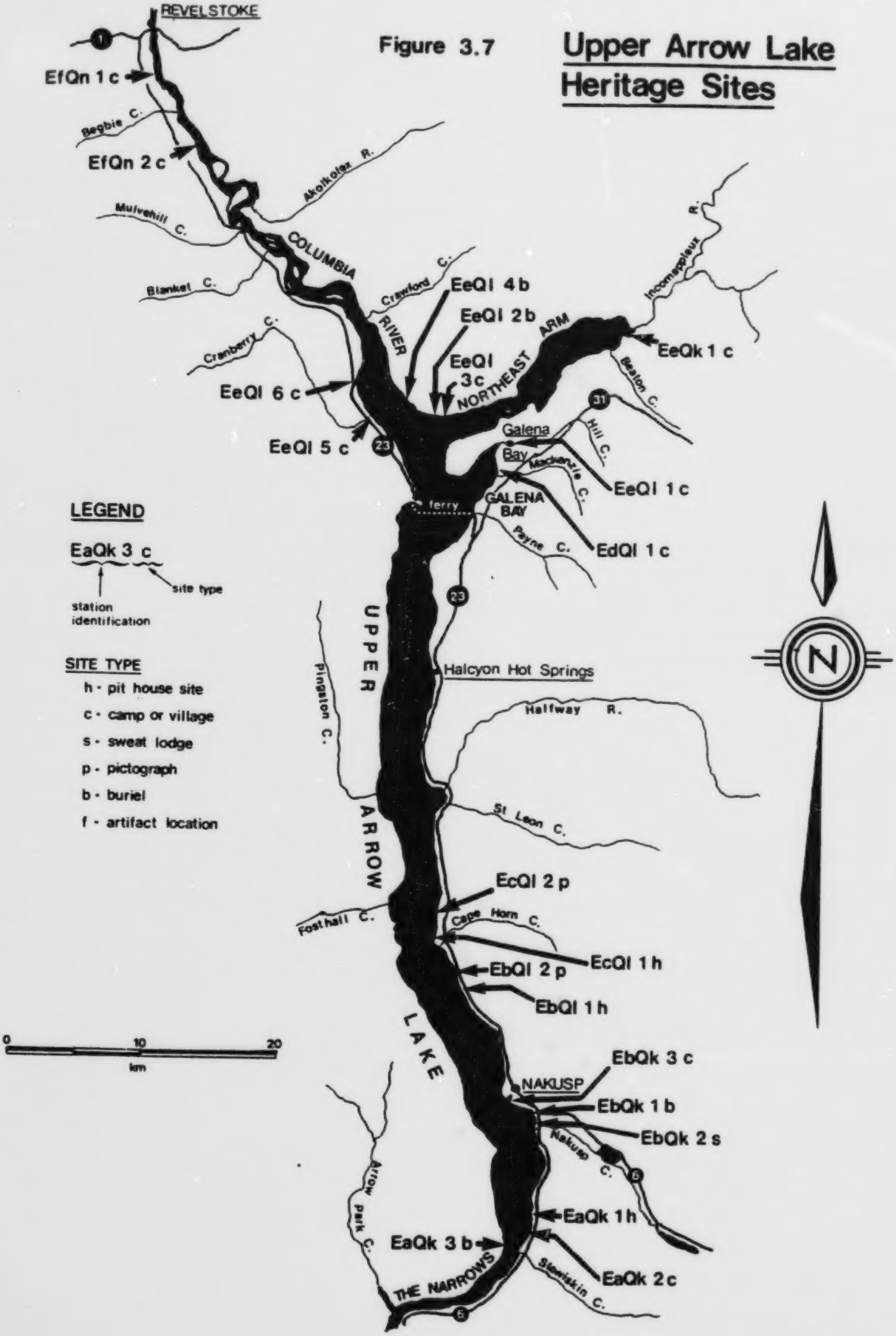
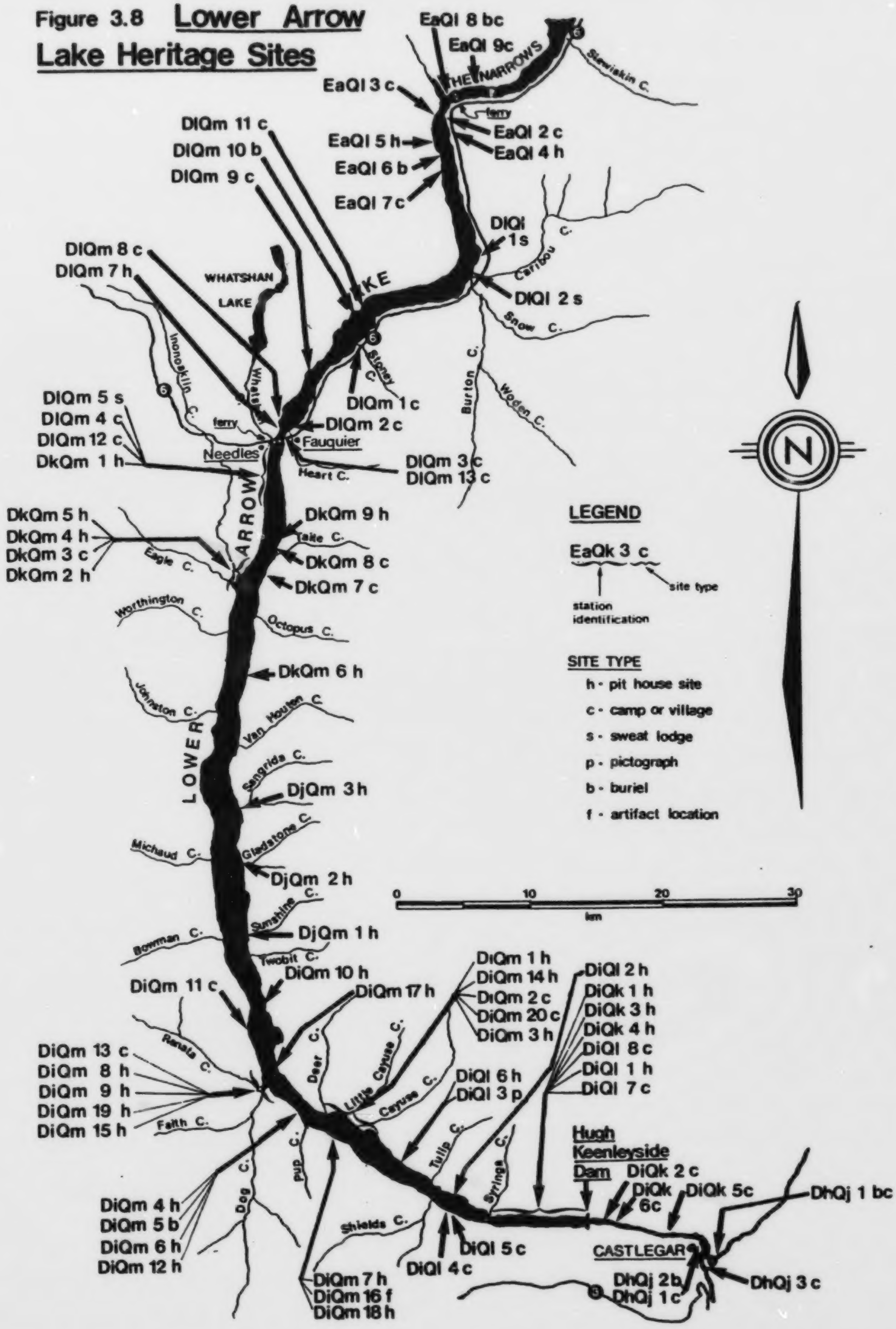


Figure 3.7 Upper Arrow Lake Heritage Sites

REVELSTOKE
1
EfQn 1 c
Begbie C.
EfQn 2 c
Akolkolex R.
Mulvehill C.
COLUMBIA
RIVER
Blanket C.
Crawford C.
Cranberry C.
EeQl 4 b
EeQl 2 b
EeQl 3 c
NORTHEAST ARM
Incomappleux R.
EeQk 1 c
Beaton C.
EeQl 6 c
EeQl 5 c
23
31
Galena Bay
Hill C.
Mackenzie C.
EeQl 1 c
ferry
GALENA BAY
Payne C.
EdQl 1 c
LEGEND
EaQk 3 c
station identification
site type
SITE TYPE
h - pit house site
c - camp or village
s - sweat lodge
p - pictograph
b - buriel
f - artifact location
UPPER
ARROW
LAKE
23
Pingston C.
Halcyon Hot Springs
Halfway R.
N
St Leon C.
EcQl 2 p
Fosthall C.
Cape Horn C.
EcQl 1 h
EbQl 2 p
EbQl 1 h
0
10
20
km
EbQk 3 c
NAKUSP
EbQk 1 b
EbQk 2 s
Nakusp C.
6
Arrow Park C.
EaQk 1 h
EaQk 3 b
EaQk 2 c
Stobiskin C.
THE NARROWS
6

Figure 3.8 **Lower Arrow Lake Heritage Sites**


EaQl 8 bc
EaQl 9c
THE NARROWS
Slewiskin C.
EaQl 3 c
ferry
EaQl 2 c
EaQl 4 h
EaQl 5 h
EaQl 6 b
EaQl 7 c
DlQm 11 c
DlQm 10 b
DlQm 9 c
DlQl 1s
Cariboo C.
DlQl 2 s
Snow C.
DlQm 8 c
DlQm 7 h
WHATSHAN LAKE
LAKE
6
Stoney C.
DlQm 1 c
Burton C.
Woden C.
Inonoaklin C.
Whatshan
6
DlQm 5 s
DlQm 4 c
DlQm 12 c
DkQm 1 h
ferry
DlQm 2 c
Fauquier
Needles
Heart C.
DlQm 3 c
DlQm 13 c
ARROW
DkQm 5 h
DkQm 4 h
DkQm 3 c
DkQm 2 h
Eagle C.
DkQm 9 h
Take C.
DkQm 8 c
DkQm 7 c
Worthington C.
Octopus C.
DkQm 6 h
Johnston C.
Van Houten C.
LOWER
Sangrida C.
DjQm 3 h
Michaud C.
Gladstone C.
DjQm 2 h
Sunshine C.
DjQm 1 h
Bowman C.
Twobit C.
DiQm 10 h
DiQm 11 c
DiQm 17 h
DiQm 1 h
DiQm 14 h
DiQm 2 c
DiQm 20 c
DiQm 3 h
DiQl 2 h
DiQk 1 h
DiQk 3 h
DiQk 4 h
DiQl 8 c
DiQl 1 h
DiQl 7 c
Renata C.
Deer C.
Little Cayuse C.
Cayuse C.
DiQm 13 c
DiQm 8 h
DiQm 9 h
DiQm 19 h
DiQm 15 h
Faith C.
DiQl 6 h
DiQl 3 p
Pup C.
Tulip C.
Syringa C.
Hugh Keenleyside Dam
DiQk 2 c
DiQk 6c
DiQk 5c
DhQj 1 bc
Dog C.
DiQm 4 h
DiQm 5 b
DiQm 6 h
DiQm 12 h
Shields C.
DiQl 5 c
DiQl 4 c
CASTLEGAR
DhQj 2 b
DhQj 1 c
DhQj 3 c
3
DiQm 7 h
DiQm 16 f
DiQm 18 h
0
10
20
30
km
N
LEGEND
EaQk 3 c
station identification
site type
SITE TYPE
h - pit house site
c - camp or village
s - sweat lodge
p - pictograph
b - buriel
f - artifact location

DiQm 4 - Deer Park	430 m (1411 ft)
DiQl 6 - Grey Wolf	434 m (1424 ft)
DkQm 5 - Inonoaklin	432 m (1417 ft)
DkQm 2 - Junebug Point	427 m (1401 ft)

Six other sites were briefly tested, three of them within the pondage area. On the basis of the above excavations, Turnbull has established a prehistoric period of occupation from approximately 1300 B.C. to 300 A.D. (Sigma Resource Consultants Ltd. 1975). Little evidence was found of either earlier or later occupation although native people were living in the area at the time of European contact.

As a result of the 1961 survey and subsequent post-inundation field work (Mohs 1977), the total site inventory for the Arrow Lakes Reservoir is 110 sites, classified into the following categories (Sigma Resource Consultants Ltd. 1975):

Site Type	Number
Habitation	48
Temporary Camp Sites	37
Burials	11
Seat Lodges	6
Pictographs	5
Cache Pits	2
Fishing Stations	1

The heaviest concentration of habitation sites, which consist of a number of house pits, is between Deer Park and the confluence of Kootenay and Slocan Rivers. Burials, pictographs, sweat lodges and cache pits are all relatively rare and usually found in close association with habitation sites. Many of the sites have suffered erosion impacts since inundation (Mohs 1977).

Downstream Area

An initial heritage resource survey of land adjacent to the Columbia River below the Hugh Keenleyside Dam was conducted in 1980 and a detailed evaluative study was conducted during 1982 as part of the impact assessment for the proposed Murphy Creek Hydroelectric Project. The initial survey recorded 39 heritage sites (Baker 1983). The 1982 work was oriented only towards those sites which are at or below El. 424 m (1391 ft) and were threatened with inundation as a result of the project or with slope failure. A total of 16 such sites were evaluated. Three different site types were evaluated consisting of surface evidence of cultural depressions (habitation sites), lithic scatters and burials. The sites are indicated on Figure 3.9.

Four sites were determined to warrant conservation or mitigation procedures:

	Elevation
DhQj 1 - Brilliant	424 m (1391 ft)
DgQk 1 - Hanna Creek	420 m (1378 ft)
DiQj 21 - Pass Creek	424 m (1391 ft)
DhQk 5 - Ferry Slip	422 m (1385 ft)

As the project has not proceeded to date, no conservation work has been undertaken.

3.3.2 Settlements

Mica Reservoir

The Mica Reservoir area is sparsely settled, due mainly to its rugged landscape and climate, and lack of access. The village of Valemount (pop. 1161)[1], clustered at the north end of the reservoir, is the major employment, transportation, retailing and service center for the northern half of the reservoir region. Donald Station is a small community at the south end of the reservoir (Figure 2.1). The population of the Blaeberry - Donald area in 1986 was 187. A sawmill owned by Evans Forest Products is the major employer in Donald Station. Golden (pop. 3584) is located 27 km (17 mi) south of Donald Station. Golden is the major employment, transportation, retailing and service center for the southern half of the reservoir region. A small number of people still live in the Village of Mica Creek,

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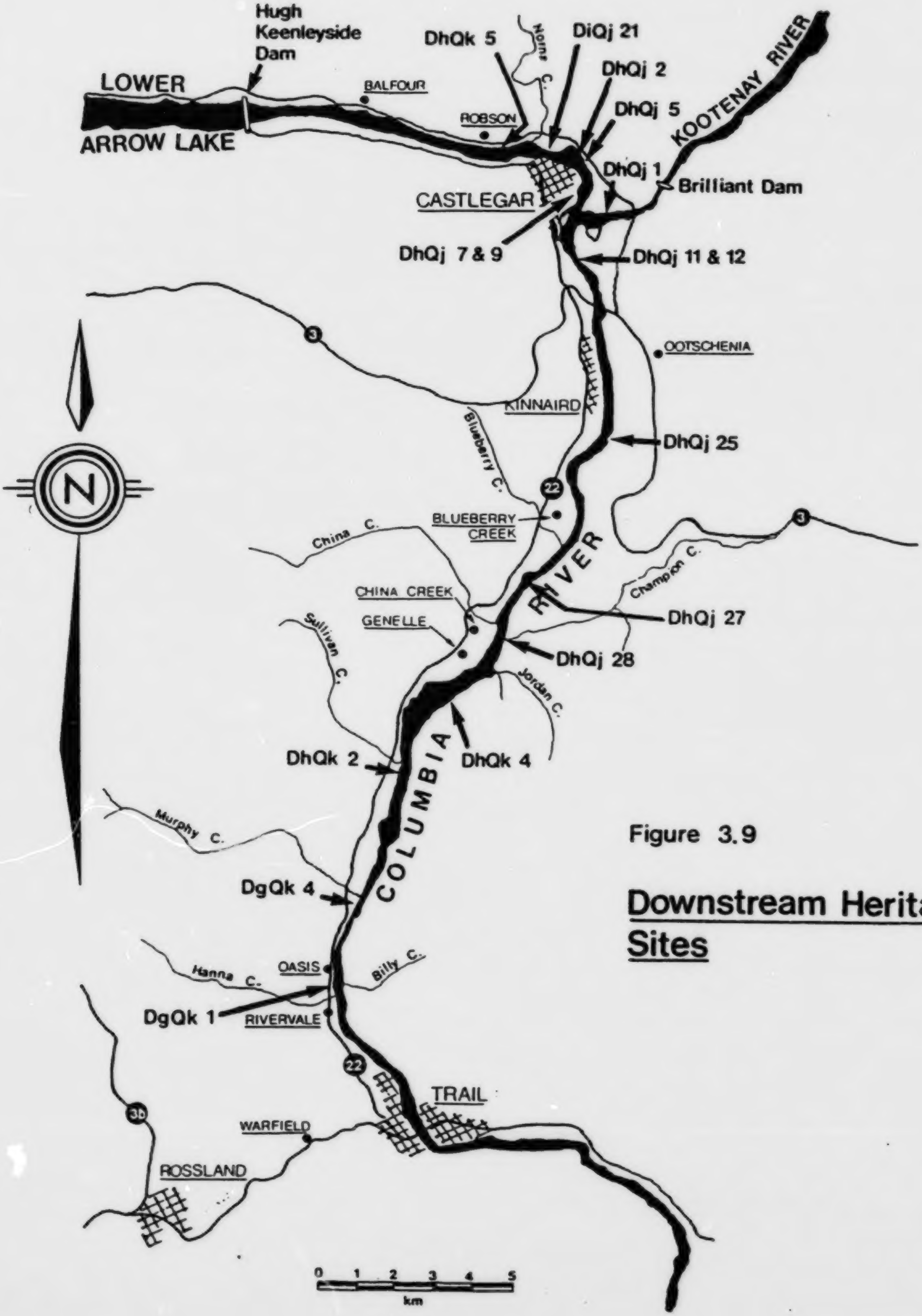
[1] All population figures are from Statistics Canada 1986 Census.



LOWER
ARROW LAKE
Hugh Keenleyside Dam
BALFOUR
ROBSON
DhQk 5
Norns C.
DiQj 21
DhQj 2
DhQj 5
KOOTENAY RIVER
DhQj 1
Brilliant Dam
CASTLEGAR
DhQj 7 & 9
DhQj 11 & 12
3
OOTSCHENIA
KINNAIRD
Blueberry C.
DhQj 25
22
BLUEBERRY CREEK
China C.
3
RIVER
Champion C.
CHINA CREEK
GENELLE
Sullivan C.
DhQj 27
DhQj 28
Jordan C.
DhQk 2
DhQk 4
COLUMBIA
Murphy C.
DgQk 4
OASIS
Hanna C.
Billy C.
DgQk 1
RIVERVALE
22
TRAIL
3b
WARFIELD
ROSSLAND
0 1 2 3 4 5
km
N

Figure 3.9

Downstream Heritage Sites

south of Mica Dam, which housed workers during construction of the dam. All communities are either on upland or groundwater water supply systems.

The northern half of the Mica Reservoir region is within the boundaries of the Fraser-Fort George Regional District, headquartered in Prince George to the west (Figure 3.10). The southern half of the reservoir is within the Columbia Shuswap Regional District, based in Salmon Arm.

Arrow Lakes Reservoir

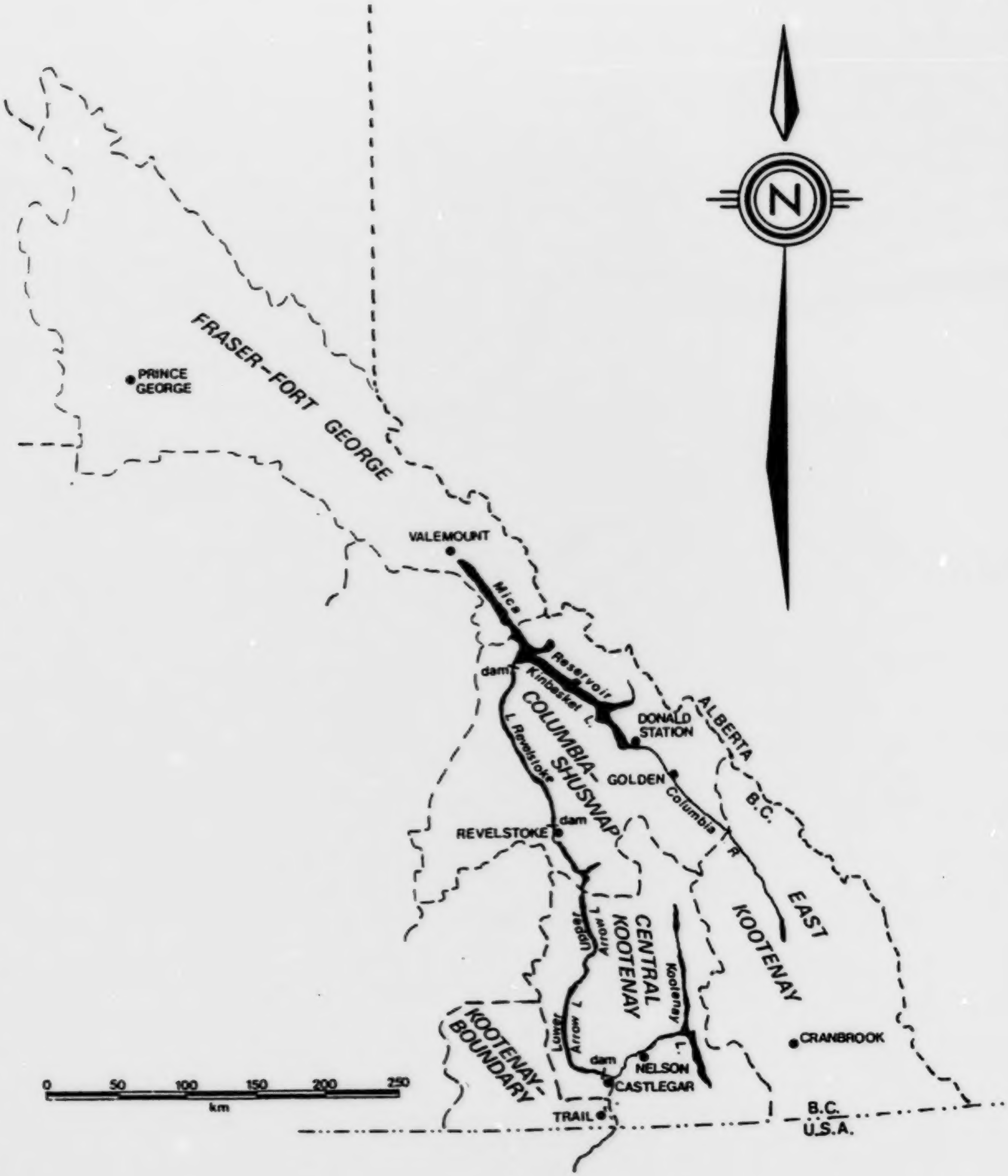
The population of the Arrow Lakes region has fluctuated considerably from the time of early settlement, related to changing patterns of resource use. As previously noted, several small communities were flooded out during creation of the reservoir. At present, the largest communities are Revelstoke, at the north end of Upper Arrow Lake, (pop. 8279), the City of Castlegar at the south end of Lower Arrow Lake (pop. 6385), and Nakusp on the southwest side of Upper Arrow Lake (pop. 1410) (Figures 2.3 and 2.4). Revelstoke and Castlegar act as sub-regional employment, transportation, retail and service centers. Smaller communities include Burton (pop. 162), Edgewood (pop. 187), and Fauquier (pop. 160) on Lower Arrow Lake.

The communities along the reservoir are sensitive to summer water levels since, in years when the reservoir does not fill, the soils of the drawdown area become very dry and dust problems can be experienced, particularly for communities such as Revelstoke and Burton, which are adjacent to large expanses of drawdown area (Sigma Resource Consultants 1979). B.C. Hydro has implemented seeding programs near the affected communities to mitigate dust problems.

There are also several minor settlements in rural areas such as Galena Bay, West Arrow Park and Needles. The Regional District of Central Kootenay, based in Nelson, encompasses Lower Arrow Lake and most of Upper Arrow Lake (Figure 3.10). The northern portion of Upper Arrow Lake is within the Columbia Shuswap Regional District.

All communities other than Castlegar obtain their water from upland or ground water sources. Castlegar obtains its water supply from an intake on the Arrow Lakes Reservoir

Figure 3.10 **Regional District Boundaries**


N
PRINCE GEORGE
FRASER-FORT GEORGE
VALEMOUNT
Mica
Reservoir
Kinbasket L.
dam
COLUMBIA-SHUSWAP
L. Revelstoke
DONALD STATION
ALBERTA
B.C.
GOLDEN
Columbia R
REVELSTOKE
dam
EAST KOOTENAY
CENTRAL KOOTENAY
Upper Arrow L.
Lower Arrow L.
Kootenay L.
KOOTENAY-BOUNDARY
dam
NELSON
CASTLEGAR
TRAIL
CRANBROOK
B.C.
U.S.A.
0
50
100
150
200
250
km

which is owned and operated by Celgar Pulp Co. Approximately 6 to 8 m^3 per minute (212 to 283 ft^3/min) of water is supplied, which is then treated by the City (D. Wiggin, Plant Engineer, Celgar Pulp Co., pers. comm., April 24, 1989). The intake extends into the reservoir and is designed to operate at the present minimum reservoir operating level. No problems have been experienced with the present reservoir operating regime. The intake is discussed in greater detail in Section 3.4.1. There are only two domestic household water supply licences issued for the reservoir itself.

Downstream Area

The largest community downstream of Castlegar is the City of Trail (pop. 7948) (Figure 2.5). Trail is a major urban center in the region, with a stable economic base focussed on the large Cominco smelter, refinery and fertilizer complex. Trail also serves as a service center for the many smaller communities located in the region.

The rural communities of Balfour subdivision, Robson, Raspberry, and Brilliant abut one another along the north bank of the Columbia River between the Hugh Keenleyside Dam and Castlegar. Past Castlegar there are numerous communities along both sides of the river, including Ootischenia, Blueberry/Fairview, China Creek/Genelle, Oasis, and Rivervale. These smaller communities are basically residential settlements with a semi-rural character. The boundary between the Regional District of Central Kootenay and the Regional District of Kootenay Boundary crosses the Columbia River between Blueberry/Fairview and China Creek/Genelle (Figure 3.10).

The Cominco operation at Trail is one of the largest in the world, with approximately 2000 employees. Cominco owns and operates a water intake on the Columbia River which provides process and in-plant drinking water. As well, the intake supplies water to the Village of Warfield (pop. 1840) and the Tadanac subdivision of Trail. Water is treated by Cominco and sold in bulk to these users (M. Lipchuk, Utilities Superintendent, Cominco Ltd., pers. comm., April 26, 1989).

The capacity of the water intake is 273 m^3 per minute (9640 ft^3/min) and the average intake ranges from 191 to 196 m^3 per minute (6744 to 6921 ft^3/min). The river flow needed to maintain the intake adequately is 425 m^3/s (15,000 ft^3/s), or a water level of El. 410.5 m

(1347 ft) (termed the O level). The actual elevation of the intake pipe is slightly below this. Normally the river level is about 2.4 m (8 ft) above the O elevation level. Occasionally, the river flow decreases to the O level (M. Lipchuk, Utilities Superintendent, Cominco Ltd., pers. comm., April 26, 1989). If the intake is run at the O level for an extended period of time, mechanical problems and increased wear on the pumps will result. However, there are no problems with the intake with the present reservoir operating regime. Prior to the installation of the Hugh Keenleyside Dam, turbidity problems were encountered during high river flows, but these have largely been eliminated due to the settling pond action of the reservoir (M. Lipchuk, Utilities Superintendent, Cominco Ltd., pers. comm., April 26, 1989).

Other than Warfield and Tadanac subdivision, communities downstream of Castlegar to the U.S. border rely on upland or groundwater sources for their water supply.

The Columbia River is used to load water bombers used to fight forest fires in the region. An intake pipe extends into the river just upstream of the highway bridge linking Castlegar and the eastern side of the Columbia River and water is pumped out. Low flows presently necessitate repositioning of the pipe (L. Flynn, BCHPA, pers. comm., June 14, 1989). Ministry of Forests personnel require notification if releases are going to decrease rapidly.

3.3.3 Access

Mica Reservoir

The main road access points to Mica Reservoir are:

1) near Valemount via the Yellowhead Highway (Highway 5) (Figure 2.2);

2) at Mica Dam via Highway 23 from Revelstoke; and

3) near Donald Station (approximately 24 km (15 miles) north of Golden) via the Trans Canada Highway (Highway 1).

At each of these points forestry roads extend for varying distances along the banks of the reservoir.

The southern portion of the Mica Reservoir at Donald Station and Golden is accessible via the Canadian Pacific Railway mainline linking B.C. to the rest of Canada. The northern part of the reservoir at Valemount is accessible via the Canadian National Railway mainline.

Arrow Lakes Reservoir

At the north end of the Arrow Lakes Reservoir, Highway 23 links Nakusp with Revelstoke and the Trans Canada Highway via a ferry across the Upper Arrow Lake between Galena Bay on the east side and Shelter Bay on the west side (Figure 2.3).

Lower Arrow Lake is accessed via Highway 6 from Vernon to the northwest with a ferry across the lake linking Needles on the west side and Fauquier on the east side (Figure 2.4). There is also a small ferry between Arrow Park and East Arrow Park at the northern end of Lower Arrow Lake. Highway 6 continues north to Nakusp to join Highway 23. At the south end of Lower Arrow Lake, Highway 3 provides access to Castlegar. Minor roads extend for varying distances along each bank of the reservoir. The Canadian Pacific Railway links Nakusp with Castlegar and Trail to the south.

There are B.C. Ministry of Highways ferries which traverse the reservoir (Shelter Bay/Galena Bay, Needles/Fauquier and Arrow Park/East Arrow Park). None of these experience navigation problems with the present reservoir operating regime. At low reservoir levels, the current from Mosquito Creek (Arrow Park Creek) on the west side of the Narrows is such that stress is put on the cables, and they must be replaced once a year. This current can also wash out the gravel on the ferry approach road, so that maintenance work is required (K. Davies, Area Manager, Ministry of Highways, Nakusp, pers. comm., September 28, 1989).

Downstream Area

Castlegar and Trail and the surrounding communities downstream of the Hugh

Keenleyside Dam are accessible via a number of major routes (Figure 2.5). Highway 3 provides access from the southern interior to Castlegar, and proceeds east via a bridge across the Columbia River to Ootischenia. Highway 22 links Castlegar and Trail and the smaller communities to the south. As noted, the Canadian Pacific Railway connects Trail and Castlegar with the Arrow Lakes Reservoir at Nakusp.

3.4 Resource Uses

3.4.1 Forestry

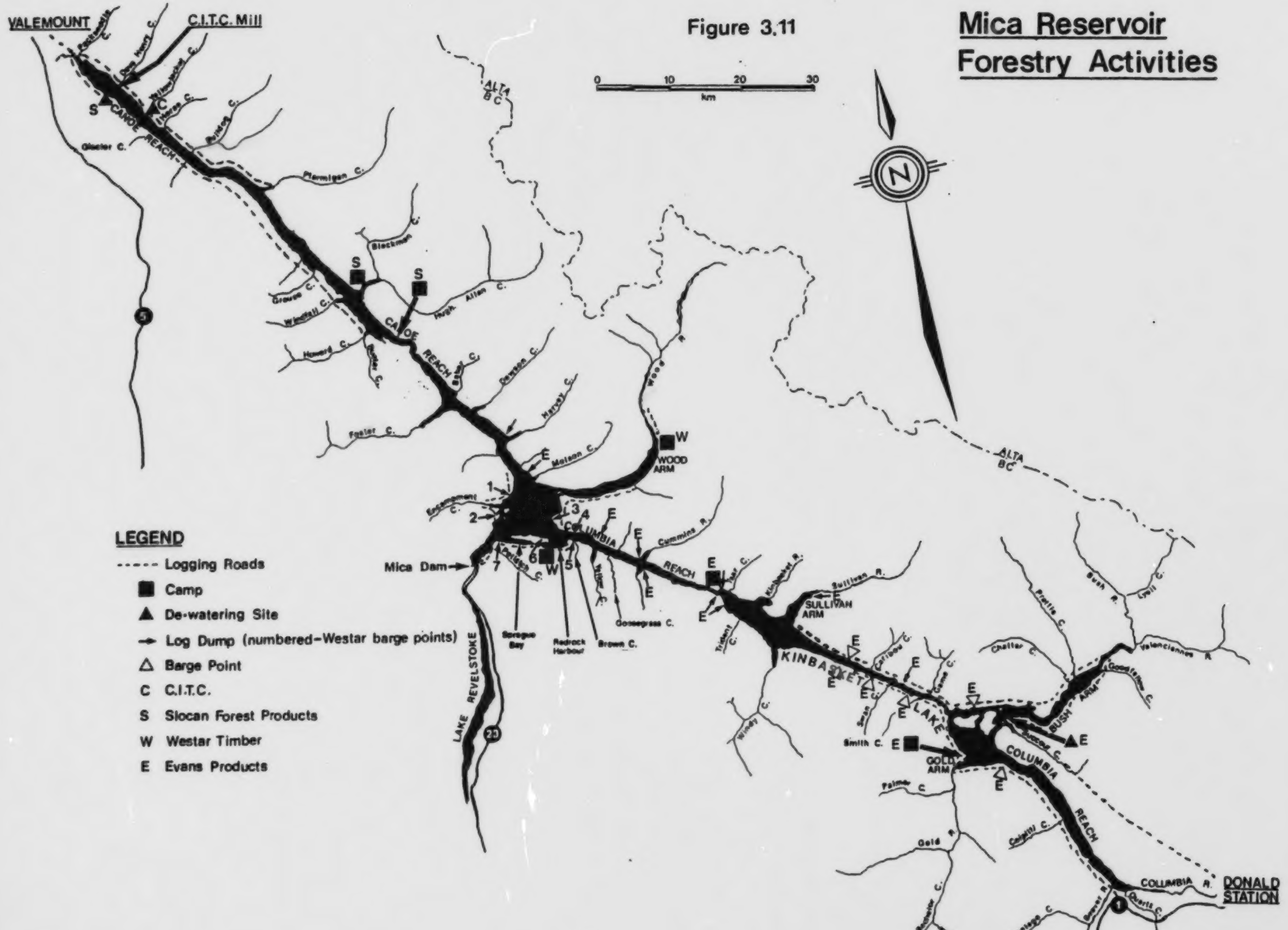
Mica Reservoir

Forestry is the dominant industry and sustains most of the area's labour force. As previously noted, most of the land surrounding the Mica Reservoir is Crown land under various forestry use tenures.

The reservoir and adjacent upland areas fall within three Timber Supply Areas (TSA) which are managed by the B.C. Forest Service. These are the McBride TSA, which covers the northern portion of the reservoir, including Canoe Reach; the Revelstoke TSA, which includes a very small area between the Mica Dam and Goosegrass Creek on the west side of the reservoir; and the Golden TSA, which covers the southern portion of the reservoir, including Bush Arm and Wood Arm. The major operator in the Canoe Reach area of the McBride TSA is Slocan Forest Products, which operates the largest sawmill in the area, at Valemount. Slocan has used the reservoir extensively in the past to move logs to its sawmill but is gradually phasing out its reliance on water transport as roads are built. Logging roads now extend from Valemount to Ptarmigan Creek on the east side of the reservoir and to Howard Creek on the west side (Figure 3.11). It is anticipated that less than 10% of Slocan's cut will be moved on the reservoir in future (S. Telton, Slocan Forest Products, pers. comm. Dec. 5, 1988). Slocan has encountered problems in water transport operations in the past due to fluctuating reservoir levels and consequently has moved its booming and log dump sites several times. The company now maintains a log removal and dewatering site with a railroad to move log bundles on the west side of the reservoir approximately 16 km (10 mi) south of Valemount (Figure 3.11). The railroad extends to about El. 744 m (2440 ft) and the site is usable only three months a year when water levels

Mica Reservoir Forestry Activities

Figure 3.11



VALEMOUNT
C.I.T.C. Mill
0 10 20 30
km
N
ALTA
BC
CANOE REACH
COLUMBIA REACH
KINBASKET LAKE
WOOD ARM
SULLIVAN ARM
BUSH ARM
GOLD ARM
Mica Dam
LAKE REVELSTOKE
DONALD STATION
COLUMBIA R.
Sprague Bay
Redrock Harbour
Brown C.
Goosegrass C.
Smith C.
Glacier C.
Ptarmigan C.
Blackman C.
Hugh Allan C.
Grouse C.
Windfall C.
Howard C.
Butler C.
Bates C.
Dawson C.
Harvey C.
Foster C.
Molson C.
Encampment C.
Cummins R.
Wood R.
Sullivan R.
Kinbasket R.
Windy C.
Trident C.
Cariboo C.
Swan C.
Palmer C.
Gold R.
Bachelor C.
Succour C.
Prattle C.
Chatter C.
Bush R.
Lyell C.
Valenciennes R.
Goodfellow C.
Cairnes C.
Quartz C.
Blaeberry R.
Ventego C.
5
23
1
2
3
4
5
6
7
S
C
W
E
LEGEND
Logging Roads
Camp
De-watering Site
Log Dump (numbered–Westar barge points)
Barge Point
C C.I.T.C.
S Slocan Forest Products
W Westar Timber
E Evans Products

are high and ice and snow do not pose problems (S. Telton, pers. comm., October 12, 1989). Two logging camps are maintained on the reservoir, one at Hugh Allen Bay and one about five km (three mi) to the south. These are not affected by reservoir levels. The company has preliminary plans to develop recreation sites on the reservoir in future but no details of these plans are available at present (S. Telton, Slocan Forest Products, pers. comm., December 5, 1988).

Another operator in the area is Bell Pole. Bell Pole has a very small cut allowance in the area and Slocan Forest Products does all of Bell's logging. The reservoir is not used at present for transporting Bell's logs but will be used in the next 10 years when the Dawson Creek section of Bell's interest area is logged.

A small sawmill owned by Canadian International Timber Corporation is situated on the reservoir near Dave Henry Creek approximately 13 km (8 mi) southeast of Valemount (Figure 3.11). The mill produces cedar specialty products and the company has two forest license areas where logging takes place. The reservoir is used occasionally to transport and store logs although fluctuating lake levels pose problems for removal and storage. A dewatering site is located on the property and the company also maintains a dewatering site at Yellowjacket Creek. The company also has a log dump at Harvey Creek.

Slocan Forest Products, Bell Pole and Canadian International Timber Corp. are the three main operators in the McBride TSA. However, there is a small 20 year cutting area bordering the reservoir just south of Valemount where small business operators can obtain harvesting licenses from the Ministry of Forests. A few small business operators also have licenses to salvage cedar, which maintains its quality even when submerged in water. These operators cut the cedar into shake blocks and truck them to Valemount (G. Feldinger, Small Business Enterprise Program, Ministry of Forests, McBride TSA, pers. comm., April 24, 1989). Salvaged cedar logs are also boomed south to Evans' sawmill at Donald or to Mica Dam where they are cut into cedar blocks.

Two companies do most of the harvesting in the small portion of the Revelstoke TSA which borders Mica Reservoir around Mica Dam: Bell Pole Co. Ltd. and Arrow Lakes Cedar Pole. A small number of Timber Sale Licenses are also held by small business operators in an area bordering the reservoir in the vicinity of Nagle Creek. Both Arrow

Lakes Cedar Pole and Bell Pole have small harvesting quotas. Bell Pole uses trucks and roads for transporting its logs. Arrow Lakes Cedar Pole is not presently using water transport although in 1987 they logged in the Goosegrass Creek area, which is not accessible by road, and used the lake for transporting the crew from Westar's logging camp at Redrock Harbour to the site and for towing bundles of logs to Redrock Harbour for dewatering (J. Archer, Arrow Lakes Cedar Pole, pers. comm., Nov. 28, 1989) (Figure 3.11). Because of reservoir fluctuations, logging was possible only during summer months. The biggest problem faced by industry is fluctuating water levels which necessitates keeping equipment on site to clear mud and debris from ramps (J. Archer, pers. comm., November 28, 1988). If Arrow sells its logs to Evans Forest Products in future, they will be dumped at Redrock Harbour and towed south. Otherwise Arrow will use road transport for its future operations.

Westar Timber Corporation is a major operator in the northern portion of the Golden TSA. The company has a logging camp at Wood Arm and also recently purchased the Redrock Harbour logging camp (Figure 3.11). Their logging operations supply a sawmill located in Malakwa near Revelstoke. A ferry-type system is used to barge logging trucks across the reservoir (D. Clapperton, Resource Officer, Timber, Golden Forest District, pers. comm., December 5, 1988; R. Jacquard, Area Forester, Westar Timber Corp., pers. comm., October 16, 1989). Westar moves all logs across the reservoir using the more expensive method of transporting loaded logging trucks on barges, rather than towing bundles of logs, as towing is not possible on a year-round basis due to the changing reservoir levels. Three crossings are actively used: Redrock Harbour - Wood Arm; Brown Creek - Wood Arm; and Sprague Bay - Encampment Creek (Figure 3.11) (R. Jacquard, Area Forester, Westar Timber Corp., pers. comm., October 16, 1989). Brown Creek is more sheltered than Redrock Harbour and is used when weather conditions make the Redrock Harbour crossing unsafe. Because Westar maintains a year-round operation, the company has extended all access ramps to low water. These ramps must be rebuilt every year due to wave action damage from fluctuating reservoir elevations. A cat or front end loader must be kept on hand at all times to assist trucks off the barges through the newly exposed mud when water levels are dropping rapidly. As well as these costly adaptations to the reservoir operation, the other major problem for log transport on the reservoir is due to floating debris which piles up on ramps and causes boat damage (R. Jacquard, Westar, pers. comm, October 16, 1989). This debris is mainly from standing trees on the reservoir bottom which periodically break off and float to the surface. BCHPA has recently implemented a floating debris removal program (discussed further in Section 3.4.3).

Evans Forest Products is the biggest licensee in the Golden TSA and the major user of the southern half of the reservoir for log transport. The company has a large sawmill at Donald Station and a plywood plant at Golden. A major logging load extends from Donald to the Sullivan River and Evans maintains a dewatering site at the mouth of Bush Arm (Figure 3.11), where logs are removed from the reservoir, stored and transported by truck to Donald and Golden. Evans generally uses the reservoir for log transport from about mid-June or early July to mid-October. However, in 1989 water levels remained too low for Evans' use till mid-July (P. Mason, Woodlands Manager, Evans Forest Products Ltd., pers. comm., September 13, 1989). The Bush Arm log load-out has a low ramp to El. 735 m (2410 ft). However, logs would have to be transported there prior to the reservoir reaching this level as navigation is not possible over the flats at El. 739 m (2425 ft) due to protruding stumps. The main ramp at the Bush Harbour dewatering site extends to 741 m (2430 ft). From the company's point of view, the preferred range of elevations during Evans' operating period would be 741 m to 747 m (2430 ft to 2450 ft) (P. Mason, pers. comm., September 13, 1989).

Evans uses a barge for hauling equipment and supplies to its logging operations. Current barge points, log dumps, and logging camps are indicated on Figure 3.11. Each log dump has three roads and log skids to provide access to the water at different elevations. The minimum elevation for use of the log dumps is 739 m (2425 ft) (P. Mason, pers. comm., September 13, 1989).

Such extra handling adds to the costs of Evans' operations. The company's biggest problem with water transport is the low water levels in spring which necessitate rebuilding most of the dump and dewatering sites at considerable cost (B. Salmon, Forestry Manager, Evans Forest Products, pers. comm., Dec. 12, 1988). As well, fluctuating lake levels, coupled with freezing during winter months, reduce the company's operating flexibility. For example, Evans did not use logging areas accessible only by water last year because of uncertainty over lake levels. The previous year, water levels were so low (between 725 and 732 m (2380 - 2400 ft)) that the company had to build a costly temporary ramp system to dump the logs (P. Mason, pers. comm., September 13, 1989). Another problem for Evans has been that the original network of roads was flooded with creation of the reservoir so that new roads have had to be built with concomitant high costs. While BCHPA compensated Evans for the loss of original roads, according to Evans' staff, the compensation package was not adequate as the implications of flooding on forest management around the lake were not identified or fully understood (P. Mason, pers. comm., September 13, 1989). In spite of these problems, Evans plans to accelerate its use of the reservoir for log transport in the future, as areas which are inaccessible by road are logged.

Arrow Lakes Reservoir

The majority of land surrounding the Arrow Lakes Reservoir is within Tree Farm Licence (TFL) #23 owned by Westar Timber Corporation. Minor portions of the Arrow TSA adjacent to the reservoir are interest areas of Slocan Forest Products, Bell Pole and Small Business Areas.

Westar has a very large sawmill operation just northwest of Robson near Castlegar. The mill employs approximately 350. Logs for this mill are supplied from TFL #23 and are transported predominantly via the reservoir. Westar moves 800,000 m (2,624,800 ft) of wood on the reservoir annually (D. Haines, Marine Department, Westar Timber, pers. comm., September 25, 1989). Approximately 90% of Westar's log storage and transport operation is by water (J. Lelacheur, Area Manager, Westar Timber, pers. comm., Dec. 12, 1988). Westar is the only company using the reservoir for log transport.

Westar moves its log dumping sites periodically, depending on the location of logging operations within the TFL. At present, there are nine working log dumps around the reservoir (Figures 3.12 and 3.13) (C. Barlow, Marine Manager, Westar Timber Corp., pers. comm., April 27, 1989). Each dump has three or four roads and log skids into the lake at various elevations to provide access to the lake most or all of the year. Logs are trucked to the dump sites, unloaded, sorted and made into cabled bundles which are then reloaded onto trucks and taken to the appropriate skid. Problems begin to be experienced when the water level is at about El. 427 m (1401 ft) (C. Barlow, Marine Manager, Westar Timber, pers. comm., April 27, 1989). The company attempts to limit log towing during low water period (mid-January to mid-May). The costs of unloading and reloading as well as maintaining the roads and skids, which encounter mud and rust problems at low reservoir

Figure 3.12

Upper Arrow Lake Forestry Activities

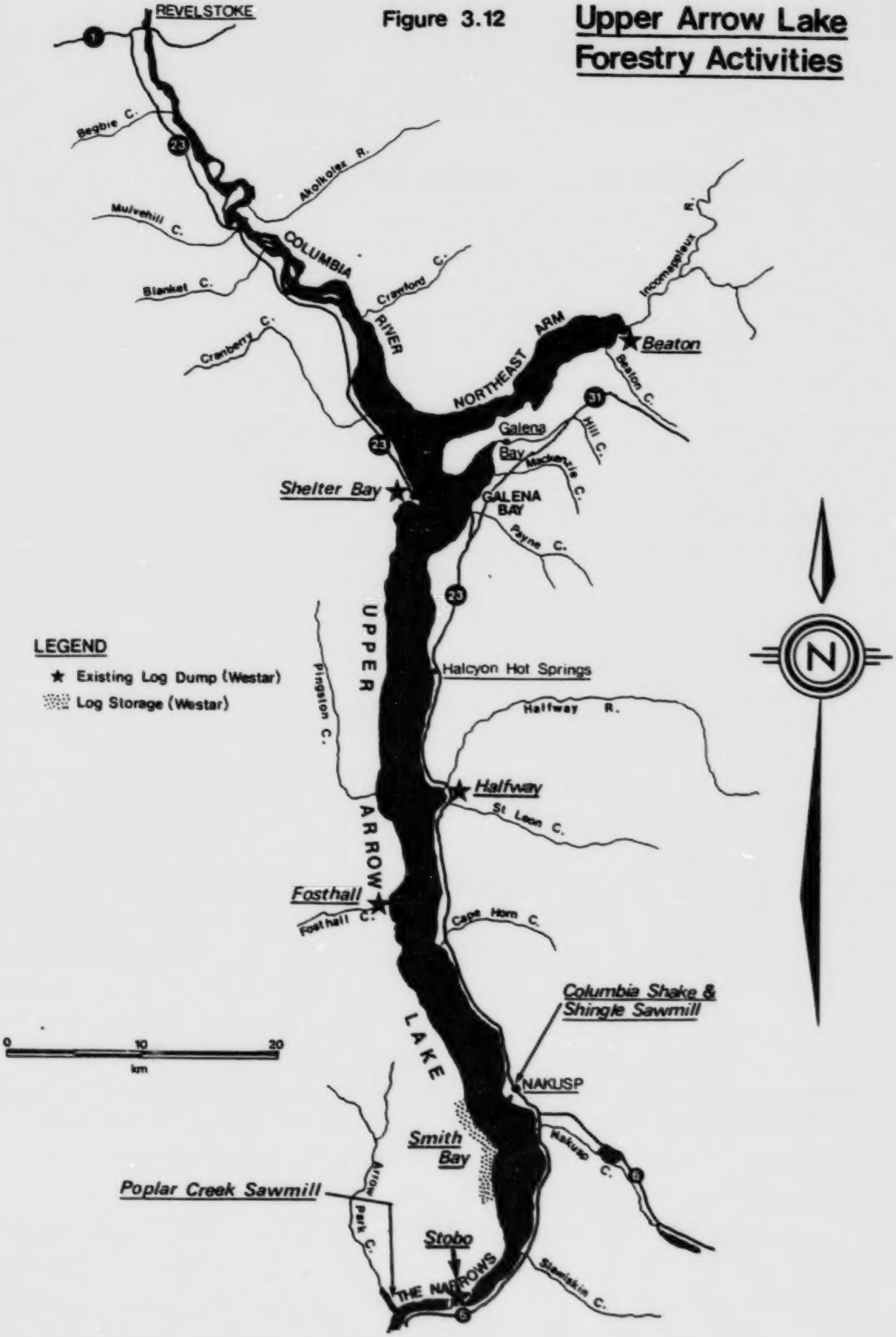
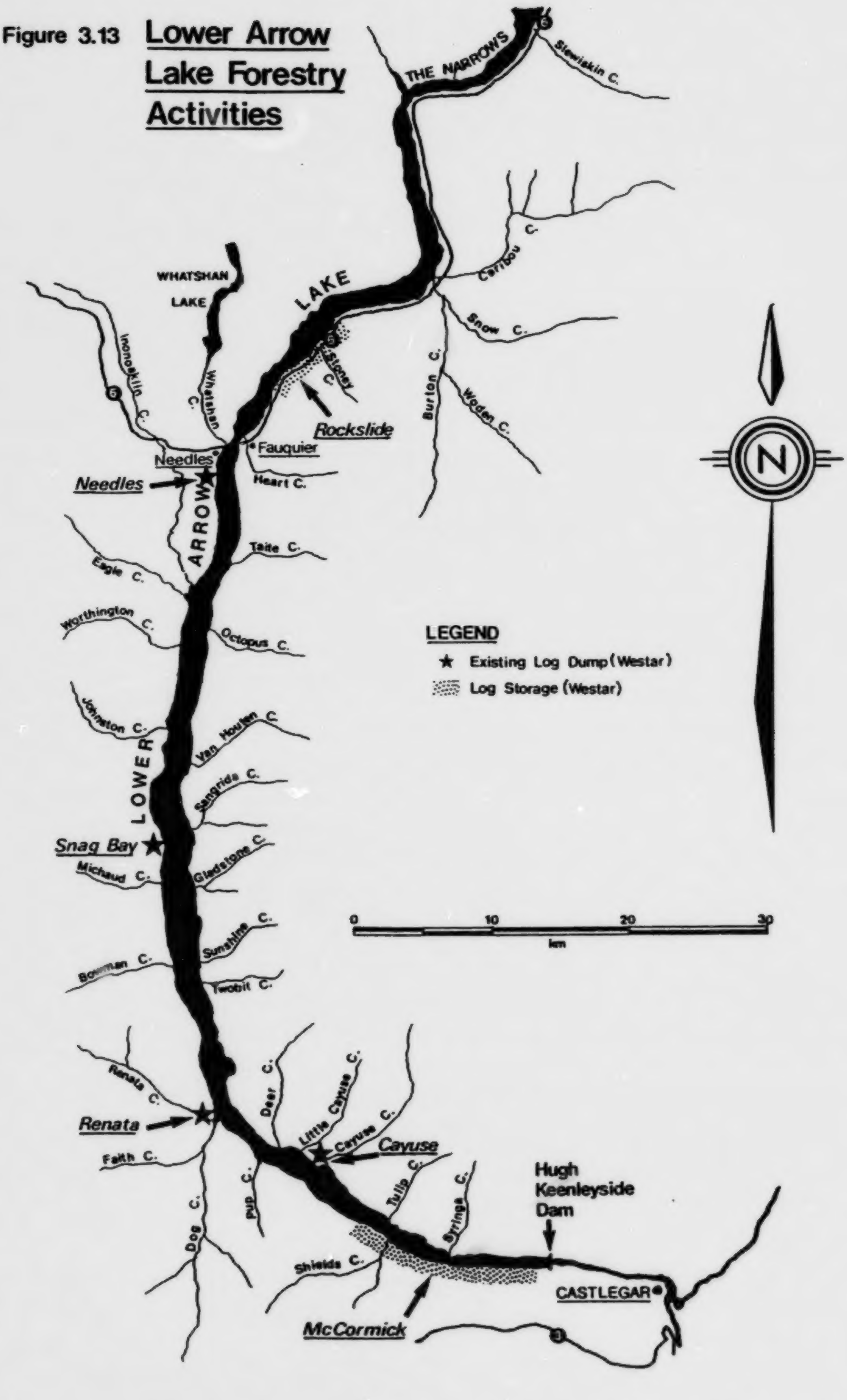

REVELSTOKE
1
Begbie C.
23
Akolkolex R.
Mulvehill C.
COLUMBIA
Blanket C.
Crawford C.
Cranberry C.
RIVER
Incomappleux R.
NORTHEAST ARM
Beaton
Beaton C.
31
Hill C.
Galena
Bay
Mackenzie C.
23
Shelter Bay
GALENA BAY
Payne C.
23
UPPER
LEGEND
★ Existing Log Dump (Westar)
Log Storage (Westar)
Pingston C.
Halcyon Hot Springs
Halfway R.
Halfway
St Leon C.
ARROW
Fosthall
Fosthall C.
Cape Horn C.
Columbia Shake & Shingle Sawmill
0
10
20
km
LAKE
NAKUSP
Smith Bay
Nakusp C.
6
Poplar Creek Sawmill
Arrow Park C.
Stobo
THE NARROWS
Saeriskin C.
6
N

Figure 3.13 **Lower Arrow Lake Forestry Activities**


THE NARROWS
Stewiakin C.
Caribou C.
Snow C.
Burton C.
Woden C.
WHATSHAN LAKE
LAKE
Inonoaklin C.
Whatshan C.
Stoney C.
Rockslide
Fauquier
Needles
Needles
Heart C.
ARROW
Taite C.
Eagle C.
Worthington C.
Octopus C.
LEGEND
★ Existing Log Dump (Westar)
▨ Log Storage (Westar)
Johnston C.
Van Houten C.
LOWER
Sangrida C.
Snag Bay
Michaud C.
Gladstone C.
Sunshine C.
Bowman C.
Twobit C.
0
10
20
30
km
Renata C.
Renata
Deer C.
Little Cayuse C.
Cayuse C.
Cayuse
Faith C.
Pup C.
Tulip C.
Syringa C.
Hugh Keenleyside Dam
Dog C.
Shields C.
CASTLEGAR
McCormick
N
6
5
3

levels, are considerable. Two of the log dumps cannot be used at all when the reservoir is at its lowest level (J. Lelacheur, Area Manager, Westar Timber Corp., pers. comm., Dec. 12., 1988).

Each dump site has a small boom boat which separates the log bundles and forms them into rafts. These rafts are then towed by a large tug south to the lock beside the Hugh Keenleyside Dam. During winter, when reservoir levels are lowest, the large tug and rafts cannot pass through the part of the reservoir south of Nakusp known as the Narrows. This necessitates having smaller tugs on hand to break up the rafts and tow the log bundles through separately. They are reformed into rafts again and towed by the large tug to Hugh Keenleyside lock.

Logs are stored in the water just upstream of Hugh Keenleyside Dam and grounding problems are encountered at low water levels. Special rafts which can pass through the lock are made up as required by mill demand. Westar maintains a 10 man/5 tug operation to transport log rafts through the lock.

Westar makes extensive use of the three Ministry of Highways ferries traversing the reservoir. Since most of Westar's log dumps are on the west side of the reservoir, the ferries are used to transport logging trucks. Overloaded logging trucks are too heavy for the small Arrow Park/East Arrow Park ferry to handle, since its load limit is 40 tons (K. Davies, Ministry of Highways, Nakusp, pers. comm., September 28, 1989).

As well as Westar's sawmill, there is also a large pulp mill at Castlegar owned by Celgar Pulp Co. The pulp mill employs approximately 400. Celgar owns and operates a water intake located approximately 360 m (1181 ft) upstream of Hugh Keenleyside Dam. The intake supplies approximately 76 m^3 per minute (2684 ft^3/min) of process and in-plant drinking water to Celgar's pulp mill and Westar's sawmill operation (D. Wiggin, Plant Engineer, Celgar Pulp Co., pers. comm. April 24, 1989). In addition, as previously noted, Celgar provides the City of Castlegar with its drinking water from this intake (approximately 6 to 8 m^3 per minute (212 to 283 ft^3/min)). The intake pipe extends into the reservoir at about El. 405 m (1329 ft) and no problems are experienced with the present reservoir operating regime, other than occasional cloudy water during the spring runoff period.

Celgar presently uses residual wood chips supplied from sawmills in the area for its pulp. However, in the past Celgar used roundwood which was stored in bundles above the Hugh Keenleyside Dam and brought through the lock to the mill wood room as required. One week's supply of roundwood would be stored beside the mill and grounding problems were experienced when river levels were low. The possibility exists that Westar will expand its mill in the future and establish a wood room using water-transported roundwood again (D. Wiggin, Plant Engineer, Celgar Pulp Co., pers. comm., April 24, 1989).

There are two other small sawmills on the reservoir: the Columbia Shake and Shingle Mill at Nakusp owned by Tell Forest Products of Vancouver and the Poplar Creek Sawmill owned by Hunter Line Trucking Company of Salmon Arm (Figure 3.12). The Poplar Creek mill is presently a portable installation but is in the process of being made into a permanent mill. Both of these mills are supplied by Westar. The reservoir is extremely important to the Columbia Shake and Shingle Mill's operation, as Westar transports logs to the mill by water. The log bundles are generally taken apart as soon as they arrive, removed by front end loader and stored on land, although bundles are occasionally stored in the water for limited time periods. The mill maintains several log removal sites to accommodate the changes in reservoir levels throughout the year. When the reservoir is at El. 428 (1405 ft) or less, the log removal operation becomes more difficult as the distance from the dry land storage site is greater, and extra equipment and men are required, increasing operating costs (H. Lythgoe, Manager, Columbia Shake and Shingle Mill, pers. comm., April 27, 1989; C. Barlow, Marine Manager, Westar Timber Corp., pers. comm., October 23, 1989). The Poplar Creek Sawmill is supplied by truck. There are also numerous very small (one-two person) sawmills along the lake which are part of the B.C. Ministry of Forests small business program.

Downstream Area

Westar Timber Corporation's sawmill and the adjacent Celgar pulp and paper mill are the major forestry operations downstream of the Hugh Keenleyside Dam.

Westar stores log rafts on the west side of the Columbia River below the Hugh Keenleyside Dam for approximately 8 km (5 mi) till required. Differing river discharges can present problems. The optimal discharge for Westar's operation is 1416 m^3/s (50,000 ft^3/s) (C. Barlow, Marine Manager, Westar Timber Corp., pers. comm., April 27, 1989). At high discharges (about 1840 m^3/s (65,000 ft^3/s) and greater), the river current is very strong and storing and moving log bundles is difficult. At low discharges (between 198 and 255 m^3/s (7000 and 9000 ft^3/s) or less), there are difficulties floating log bundles onto the water feed lift which carries them into the mill and log stored bundles become grounded (C. Barlow, Marine Manager, Westar Timber Corp., pers. comm., April 27, 1989). At 198 m^3/s (7000 ft^3/s) or less, Westar must commence dredging to continue operations, and operations are basically shut down if discharges are kept at 142 m^3/s (5000 ft^3/s) for an extended time period. Westar presently has an agreement with B.C. Hydro that discharges will not go below 142 m^3/s (5000 ft^3/s) and that a week's notice will be given if discharges decrease to low levels. However, in practice, discharges often fluctuate to 142 m^3/s on a daily basis to meet demand from downstream, and sometimes advance notice cannot be given.

3.4.2 Agriculture

Mica Reservoir

Poor soils and a short growing season severely restrict agricultural activity in the Mica Reservoir area. Agriculture in the Valemount area is limited to the production of forage and beef cattle. Approximately 142 ha (350 acres) are cultivated (E.L.U.C. 1974b). There are no full-time farmers.

On the Columbia River floodplain between Donald and Golden, there has been only limited agriculture due to flooding. Commercial/industrial development and settlement have eliminated the earlier farms in the area. In the Blaeberry Valley, about 16 km (10 mi) northwest of Golden, some ranching takes place at higher elevations. All forage is grown on a dry-land basis. There are no full-time farmers.

Arrow Lakes Reservoir

As previously noted, the Arrow Lakes Reservoir lies in an area of climatic transition. The southern portion of the reservoir, from Edgewood to Syringa Creek has a climate similar to that of the Okanagan, with a low winter snowfall, low total precipitation, relatively long frost-free period and a warm summer. North of Edgewood, precipitation and snowfall are much greater and the frost-free period is shorter, limiting agricultural activity.

At present, there is limited agriculture in the Arrow Lakes area, mostly in the vicinity of Edgewood, Nakusp and Burton. This light agricultural activity involves mainly stock raising and production of forage crops (G. Tegart, District Agriculturalist, B.C. Ministry of Agriculture and Fisheries, Vernon, pers. comm., October 5, 1989). Approximately 5364 ha (13,250 acres) were cultivated in 1979, representing about 17% of the land with an agricultural capability rating of Class 4 or greater in the Canada Land Inventory System (Sigma Resource Consultants 1979). Overall, the area is marginal for commercial agriculture because of distance to markets.

In the northern part of the reservoir, productivity and range of crops are limited by climate and topography. The climate in the southern portion of the reservoir makes it possible to grow soft fruits such as cherries, peaches and grapes, although late frosts north of Renata limit orchard production to plums and apples. Few orchards have been developed since the original orchards were flooded by creation of the reservoir.

No irrigation or stock watering licences have been issued with the reservoir as the source of supply (B. Anderson, Water Allocation Technician, Water Management Branch, B.C. Ministry of Environment, Nelson, pers. comm., October 5, 1989).

Downstream Area

There is very little active agriculture in the vicinity of the Columbia River below the Hugh Keenleyside Dam. At present, only about 20 ha (49 acres) are cultivated (Talisman Land Resource Consultants 1984). Most formerly cultivated lands have been abandoned or converted to hobby farms, rural residential use, or other urban-related uses.

3.4.3 Recreation

Mica Reservoir

Mica Reservoir is located in one of the most scenic regions of B.C. Recreational opportunities include boating, fishing, camping, picnicking, hiking, hunting, nature study and berry picking. Due to its remoteness, lack of road access and facilities have limited recreational use of the reservoir. Extensive drawdown and accumulations of wood debris are also significant constraints to use. As noted in Section 3.4.1, BCHPA has recently implemented a debris removal program. Floating debris is collected and burned. Most collection to date has taken place at the northern end of the reservoir where there is greater accumulation of floating debris. If future reservoir levels are high enough, the program will be expanded to include debris removal from beaches which will alleviate the problem to a large extent (A. Brotherston, Senior Environmental Coordinator, BCHPA, pers. comm., November 7, 1989). Overall recreational activity is light, and confined mainly to the local population, although use has been increasing slowly over the years. Recreational use occurs mainly during the months of June through September.

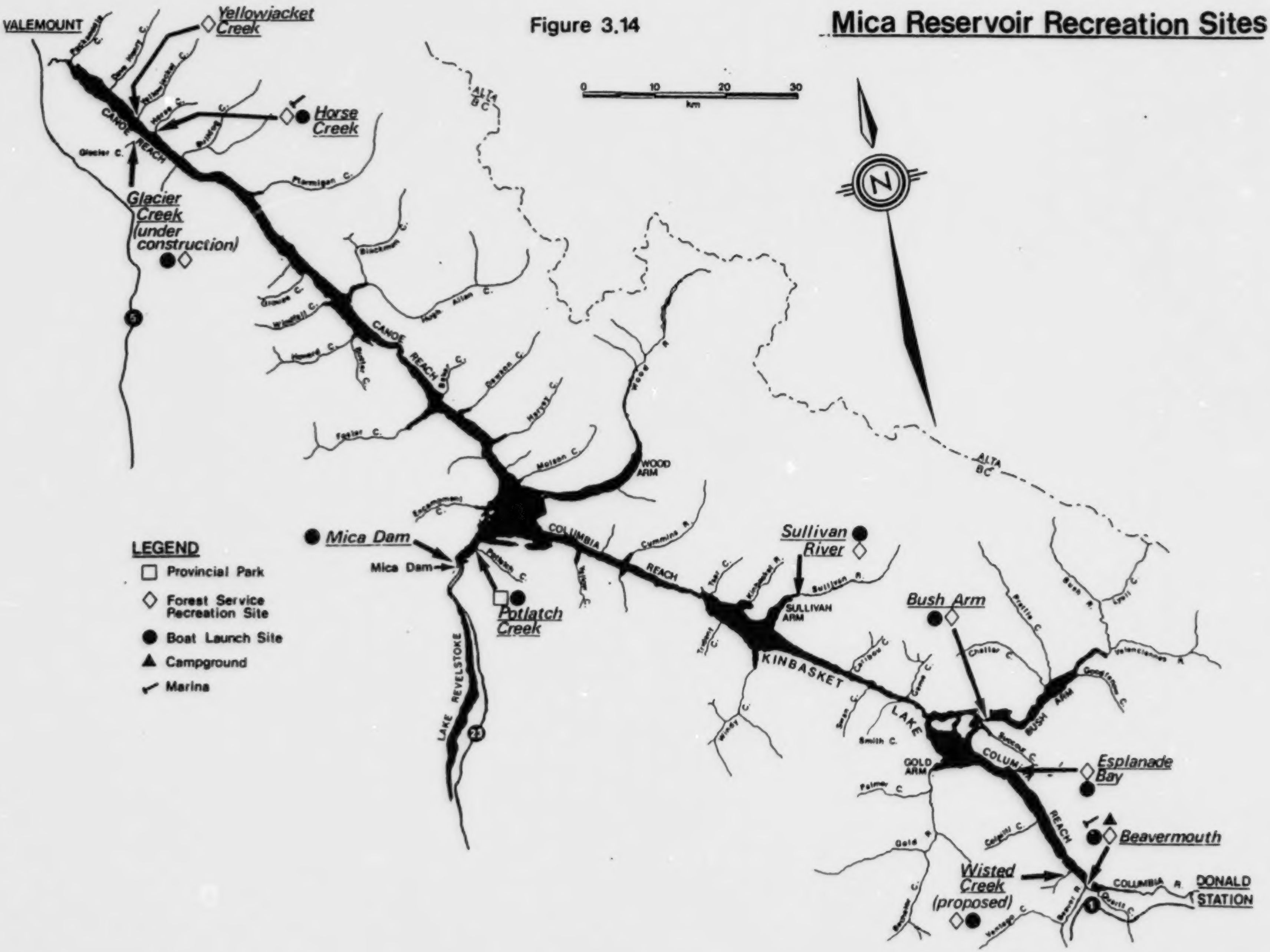
There are Forest Service recreation sites featuring rustic campgrounds and gravel boat launches at Beavermouth and Esplanade Bay at the southern end of the reservoir and at Potlatch Creek near Mica Dam (Figure 3.14).

Annual recreation activity is estimated at 500 to 700 user days at Esplanade Bay and 200 user days at Beavermouth (D. Cummings pers. comm., Dec. 6, 1988). There were 681 documented user days at the Ministry of Forests recreation site at Potlatch Creek near the Mica Dam. The site is considered heavily used and user days were more likely in the range of 4000 to 5000 (P. Frew, Resource Officer, Recreation, Revelstoke Forest District, pers. comm., Nov. 28, 1988). The Potlatch Creek site has been recently taken over by B.C. Parks. A Class A provincial park is proposed to be established with a 40 to 50 vehicle unit campsite and a concrete boat launch usable to low water (P. Whitfield, Planner, B.C. Parks, Kamloops Regional Office, pers. comm., April 26, 1989).

Recreational use, mainly sight-seeing, viewing, hunting and nature study, occurs along the Yellow Creek Forest Service Road which extends east along the reservoir from the Mica Dam. BCHPA has a gravel boat launch at Mica Dam open to the public, and a private float used for dam maintenance. As previously noted, BCHPA, in cooperation with the Canadian Parks Service, has established a Historic Site in commemoration of David Thompson's stay at Boat Encampment. Westar Forest Products' barge access ramps in the Redrock Harbour area are open to the public to launch recreational boats (Figure 3.11).

Figure 3.14

Mica Reservoir Recreation Sites


VALEMOUNT
Yellowjacket Creek
Horse Creek
Glacier Creek (under construction)
Glacier C.
Dave Henry C.
Yellowjacket C.
Horse C.
Bulldog C.
CANOE REACH
Ptarmigan C.
Blackman C.
Hugh Allan C.
Grouse C.
Windfall C.
Howard C.
Bottler C.
Baker C.
Dawson C.
Harvey C.
Foster C.
Molson C.
Wood R.
WOOD ARM
ALTA BC
0 10 20 30
km
N
5
Mica Dam
Encampment C.
Potlatch C.
Potlatch Creek
Mica Dam
LAKE REVELSTOKE
23
COLUMBIA REACH
Cummins R.
Yellow C.
Tsar C.
Kinbasket R.
Sullivan R.
SULLIVAN ARM
Sullivan River
Trident C.
KINBASKET LAKE
Windy C.
Caribou C.
Swan C.
Smith C.
Camp C.
GOLD ARM
Palmer C.
Gold R.
Bush Arm
Chatter C.
Prattle C.
Bush R.
Lyell C.
Valenciennes R.
Gorgeous C.
BUSH ARM
Succour C.
COLUMBIA REACH
Esplanade Bay
Beavermouth
Wisted Creek (proposed)
Cedars C.
Bachelor C.
Ventego C.
Beaver R.
Quartz C.
COLUMBIA R.
DONALD STATION
1
LEGEND
□ Provincial Park
◇ Forest Service Recreation Site
● Boat Launch Site
▲ Campground
Marina

There is a Forest Service recreation site near the Evans Forest Products dewatering site at Bush Harbour. This site has a small campground and a gravel boat launch. The Forest Service estimates annual recreation activity at this site is about 50 user days (D. Cummings, Resource Officer, Recreation, Golden Forest District, pers. comm., Dec. 6, 1988).

Evans Forest Products' barge access ramps along a logging road which extends northeast past Double Eddy Creek on the southwest side of the reservoir are also used for launching recreational boats (Figure 3.11).

At the north end of the reservoir in the Valemount area, there are two Forest Service recreation sites, one at Yellowjacket Creek and the other just south of Horse Creek, both on the east side of the reservoir. The Horse Creek recreation site has a gravel boat launch ramp and a small boat dock which locals refer to as the Valemount Marina.

Ministry of Forests staff in McBride estimate 1200 user days annually at the north end of the reservoir (B.C. Hydro 1988). The boat launch and campground at Horse and Yellowjacket Creeks are heavily used and are occasionally inadequate for both parking and camping. No individual user day statistics are available for these sites. The B.C. Forest Service and the Valemount Marine Association plan to upgrade the Horse Creek site in the near future, with funding from BCHPA. A 213 m (700 ft) concrete boat launch ramp, 7.3 m (24 ft) wide, extending 27 m (87 ft) below full pool is planned (C. Guernsey, BCHPA, pers. comm., August 28, 1989). The wharves of the marina will be upgraded to provide greater capacity and the campground will be enlarged.

At the south end of the reservoir, a privately operated campground, gravel boat launch and marina, the Big Lake Resort, is located at Beavermouth Creek and a private foreshore site with a gravel boat launch, dock and summer cottages developed by the Cot Gin Society is located at Esplanade Bay. In years when the reservoir does not fill, as in 1989, that portion of the reservoir south of Mica Dam, known as Columbia Reach, becomes a river with a very large exposed drawdown area. Boating activities are curtailed with consequent impacts on resort owners.

A new Forest Service recreation site is under construction at Glacier Creek on the west side of the reservoir across from Yellowjacket Creek (B. Elliot, Resource Assistant, Timber, B.C. Forest Service, McBride, pers. comm., October 19, 1989). A day-use site with a gravel boat launch usable only at full pool is planned.

A new main access logging road has been constructed reaching Sullivan River. One site, south of Sullivan River, has been constructed consisting of two vehicle units and a gravel boat launch, not usable to low water. There are also two Forest Service recreation reserves in the vicinity of Sullivan River (D. Cummings, Resource Officer, Recreation, Golden Forest District, pers. comm., Dec. 5, 1988). One is planned to have a minimum of five vehicle units and will have a gravel boat launch which will be usable to low water. There are no plans to develop the other reserve at this time.

Another new forest service recreation site is planned for development at Wisted Creek on the west side of the reservoir. It will have four or five vehicle units and a gravel boat launch usable to low water will be developed.

A moderate degree of boating activity occurs although debris poses problems for boaters. There are few, if any, houseboats on the reservoir because of the debris problem (D. Cummings, Resource Officer, Recreation, Golden Forest District, pers. comm., Dec. 5, 1988).

Facilities Inventory

Beavermouth
- Forest Service Recreation Site
- rustic campground with eight vehicle units
- gravel boat launch, extends to El. 742 m (2435 ft)
- also Big Lake Resort - private development featuring a store, campground, marina cabins, wharf and rental boats

Sullivan River
- Forest Service Recreation Site
- rustic campground with two vehicle units
- gravel boat launch not usable to low water

- nearby recreation reserve is planned to have a minimum of five vehicle units and a gravel boat launch, usable to low water

Esplanade Bay
- Forest Service Recreation Site
- rustic campground with 20 vehicle units
- gravel boat launch, extends to El. 742 m (2435 ft)
- also private recreation area developed by Cot Gin Society with dock and summer cottages

Potlatch Creek
- Former Forest Service Recreation Site (now B.C. Parks)
- rustic campground with 20 vehicle units
- gravel boat launch usable only at full pool

Mica Dam
- gravel boat launch maintained by B.C. Hydro, extends to El. 745 m (2445 ft)
- private float for dam maintenance

Bush Arm
- Forest Service Recreation Site
- rustic campground with three units
- gravel boat launch, extends to El. 735 m (2410 ft)

Glacier Creek (under construction)
- Forest Service Recreation Site
- day-use site
- gravel boat launch usable only at reservoir full pool

Yellowjacket Creek
- Forest Service Recreation Site
- rustic campground with five vehicle units

Horse Creek (Valemount Marina)

- Forest Service Recreation Site
- rustic campground with 10 parking spaces
- gravel boat launch ramp, extends to approximately El. 739 m (2425 ft) (new concrete ramp planned to extend to approximately El. 728 m (2388 ft))

Arrow Lakes Reservoir

The Arrow Lakes Reservoir is a long, scenic, easily accessible lake with a variety of interesting natural and heritage features. Stocks of hatchery- reared sport fish are an important component of recreation use by both residents and visitors. The Arrow Lakes area provides opportunities for boating, fishing, water skiing, camping, picnicking, hiking, houseboating, hot spring bathing and viewing. The dominant use season is during the months of May through September, with most use occurring during June, July and August. The high recreation potential of the Arrow Lakes has been identified by local communities, provincial agencies and the private sector, and plans to develop this potential are being pursued at various levels (B.C. Hydro 1988). Recreational use by both residents and tourists is increasing. However, at present, in years when the reservoir does not fill, access to the water is often difficult and the unattractive exposed drawdown area discourages water and foreshore use. Boating is also affected, particularly in the northern part of Upper Arrow Lake and the Narrows area. As well, dust problems are experienced in some communities near large expanses of drawdown area. BCHPA has initiated seeding programs near the affected communities to mitigate this problem.

There are three major provincial parks located at Syringa Creek, MacDonald Creek and Blanket Creek (Figures 3.15 and 3.16) (B.C. Hydro 1988). These parks provide camping, beach, and picnic areas, and, except for Blanket Creek, boat launch ramps. Minor provincial parks at Edgewood, Fauquier, Burton and Shelter Bay also provide beaches, day use areas, and boat launch facilities.

Forest Service recreation sites with rustic camping, picnic and beach areas are located at Sunshine Creek, Octopus Creek and Taite Creek (Figure 3.15). A small day use picnic/viewpoint area is located on B.C. Hydro property upstream of the Hugh Keenleyside Dam.

Figure 3.15 Upper Arrow Lake Recreation Sites

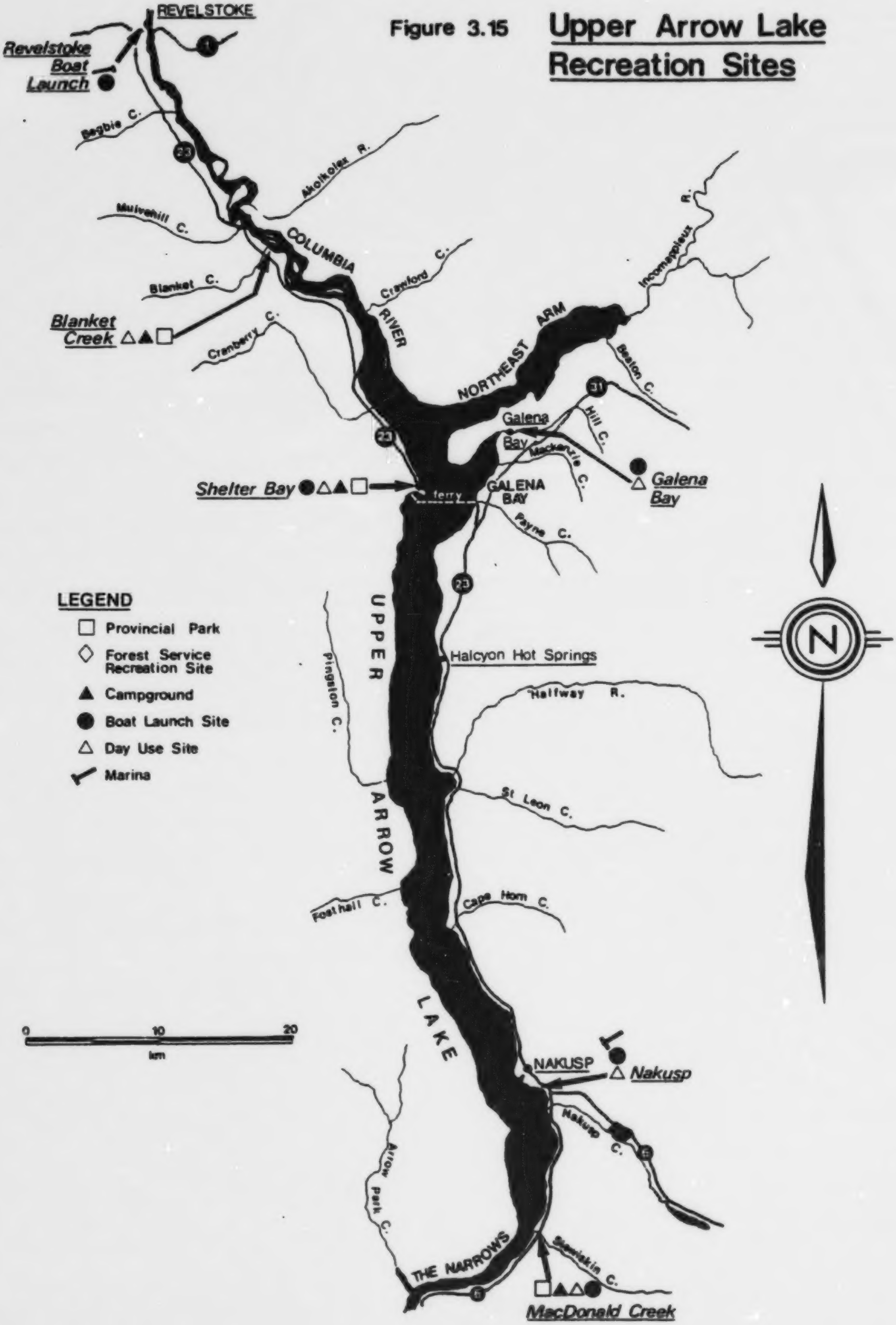
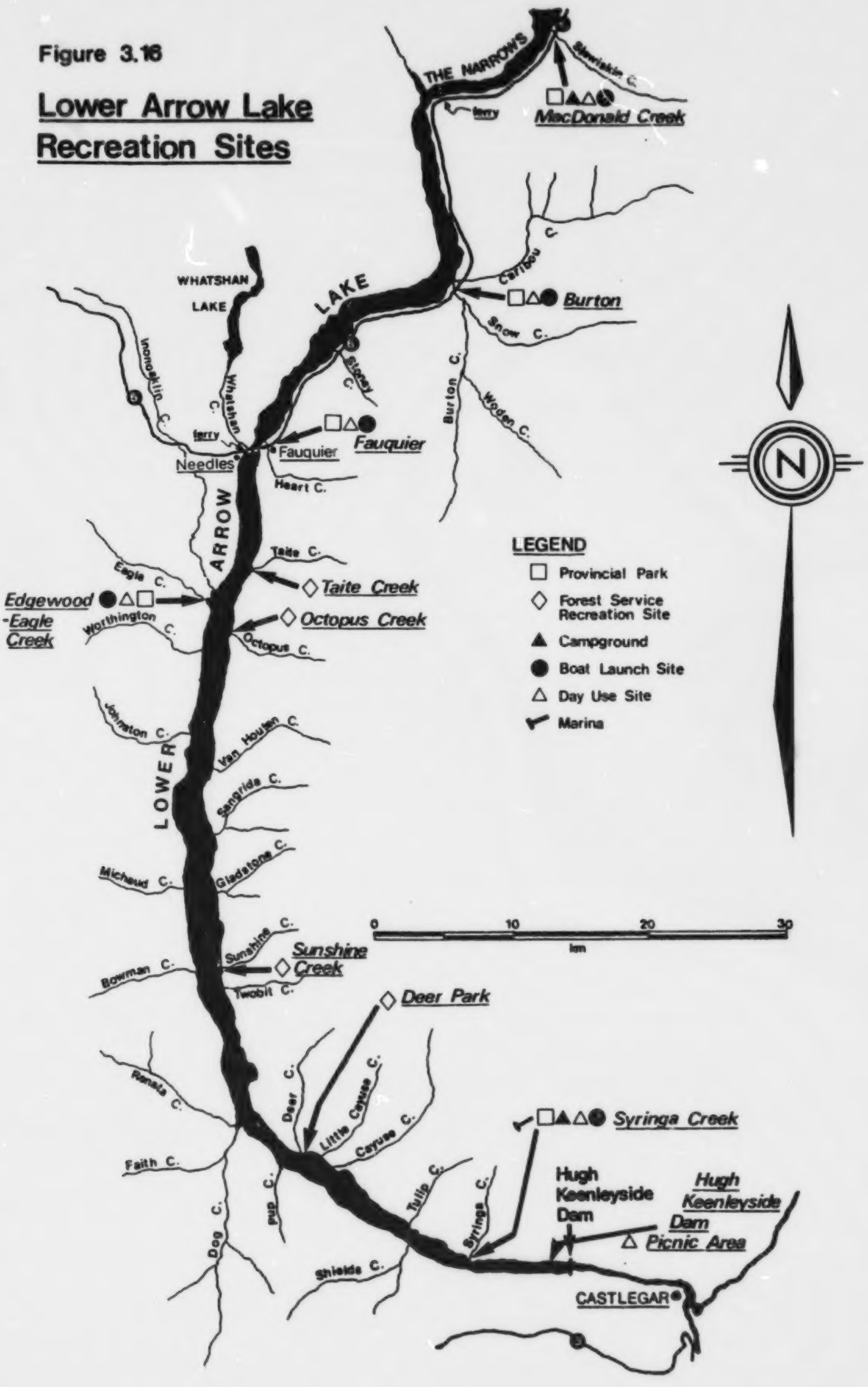

REVELSTOKE
Revelstoke Boat Launch ●
1
Begbie C.
23
Akolkolex R.
Mulvehill C.
COLUMBIA RIVER
Blanket C.
Blanket Creek △▲□
Crawford C.
Cranberry C.
Incomappleux R.
NORTHEAST ARM
Beaton C.
31
Galena Bay
Hill C.
Mackenzie C.
Galena Bay △
Shelter Bay ●△▲□
ferry
GALENA BAY
Payne C.
23
LEGEND
□ Provincial Park
◇ Forest Service Recreation Site
▲ Campground
● Boat Launch Site
△ Day Use Site
Marina
UPPER ARROW LAKE
Pingston C.
Halcyon Hot Springs
Halfway R.
St Leon C.
Foothall C.
Cape Horn C.
0
10
20
km
NAKUSP
Nakusp △
Nakusp C.
6
Arrow Park C.
THE NARROWS
6
Sleviskin C.
□▲△●
MacDonald Creek
N

Figure 3.16

Lower Arrow Lake Recreation Sites


THE NARROWS
ferry
□▲△● MacDonald Creek
WHATSHAN LAKE
LAKE
Caribou C.
□△● Burton
Snow C.
Inonoaklin C.
Whatshan C.
Stoney C.
Burton C.
Woden C.
ferry
□△● Fauquier
Fauquier
Needles
Heart C.
ARROW
Taite C.
◇ Taite Creek
Eagle C.
Edgewood -Eagle Creek ●△□
Worthington C.
◇ Octopus Creek
Octopus C.
LEGEND
□ Provincial Park
◇ Forest Service Recreation Site
▲ Campground
● Boat Launch Site
△ Day Use Site
Marina
N
Johnston C.
Van Houten C.
LOWER
Sangrida C.
Michaud C.
Gladstone C.
0
10
20
30
km
Sunshine C.
◇ Sunshine Creek
Bowman C.
Twobit C.
◇ Deer Park
Renata C.
Deer C.
Little Cayuse C.
Cayuse C.
□▲△● Syringa Creek
Faith C.
Pup C.
Dog C.
Tulip C.
Syringa C.
Hugh Keenleyside Dam
△ Hugh Keenleyside Dam Picnic Area
Shields C.
CASTLEGAR

Small communities around the reservoir maintain recreation sites with varying facilities. There are two privately-owned marinas located in the Syringa Creek area and two marinas at Nakusp, one private and one maintained by the Village of Nakusp with funding assistance from BCHPA. The marinas incur high costs due to reservoir drawdown (S. Tait, Scotty's Marina, pers. comm., September 11, 1989). For example, parking lots must be developed at different elevations, and a special anchor system must be used for the floats as marinas are moved out into the lake at low water. As previously noted, the lock at Hugh Keenleyside Dam provides access for boats between the Arrow Lakes and downstream sections of the Columbia River. The majority of boats are trailered to the lake rather than moored at marinas. The owner of Scotty's Marina at Syringa Creek estimates that at least twice as many boats are on the reservoir in summer months as those moored at marinas (S. Tait, Scotty's Marina, pers. comm., September 11, 1989).

There are private summer cottages at various locations along the reservoir, particularly between the dam and Syringa Creek, at Deer Park, and around Nakusp.

The Arrow Lakes receive moderately heavy, increasing, recreational use (B.C. Hydro 1988). B.C. Parks recorded the following attendance at five facilities during 1986 (from B.C. Hydro 1988):

Day Use - 180,000 user-days
Camping - 21,000 user-nights

B.C. Parks suggest that demand for facilities substantially exceeds supply, especially on Upper Arrow Lake (B.C. Hydro 1988). In particular, the provision of boat launch ramps and additional camping facilities between Galena Bay and Revelstoke is warranted. Marine parks providing moorage are needed. B.C. Parks is presently developing a new marine park system plan which will address the increasing use and potential of this reservoir.

The B.C. Forest Service has identified 20 potential development sites for a variety of water-based activities. As well, the Castlegar-Nakusp Community Futures Program, an economic development program, is planning to assist private sector initiatives in reservoir-related tourist facilities.

Facilities Inventory

Eagle Creek (Edgewood)
- paved road access
- steel-reinforced concrete plank boat launch ramp, 14% slope, extends to El. 420 m (1378 ft)
- dock facility
- paved 20 vehicle parking area
- picnic facilities

Fauquier
- gravel road access
- steel-reinforced concrete boat launch ramp, 12%-13% slope, extends to El. 420 m (1378 ft), protected by floating log breakwater
- dock facility
- paved 20 vehicle parking area
- small picnic area

Burton
- gravel road access
- steel-reinforced concrete plank boat launch ramp, 12% slope, extends to El. 433 m (1420 ft) and protected by floating breakwater
- dock facility
- gravel 20 vehicle parking lot
- picnic area with small parking lot

Shelter Bay
- concrete plank boat launch ramp, 12% slope, extends to El. 412 m (1376 ft), protected by a rock- filled gabion groin
- gravel 10-12 vehicle parking lot

- 13 campground units
- picnic facilities

MacDonald Creek
- concrete boat launch ramp, concrete does not extend to low water, gravel base extends beyond concrete
- large parking lot
- small picnic area with large grass play field
- small campground

Nakusp
- two marinas, one constructed by B.C. Hydro, 80 boat capacity, maintained and operated by the Village of Nakusp, and one being developed privately
- two boat launch ramps, one timber and one concrete, both extending to low water

Revelstoke Boat Launch
- concrete boat launch ramp, not usable to low water

Blanket Creek
- beach
- picnic area
- campground - 64 units

Galena Bay
- picnic area
- boat dock
- ferry ramp used for launching boats

Syringa Creek
- picnic area
- beach
- two private marinas, of approximately 180 boat capacity, with boat launch ramps extending to low water
- campground - 60 units

- two concrete boat launch ramps, 12.5% slope, one extending to El. 420 m (1378 ft) and one extending to 433 m (1420 ft)

Deer Park
- beach
- picnic area

Sunshine Creek
- Forest Service Recreation Site
- boat or vehicle access
- five vehicle units (vehicle units include picnic tables, tent pads, fire rings and a parking space.)
- beach

Octopus Creek
- Forest Service Recreation Site
- boat or vehicle access
- one vehicle unit

Taite Creek
- Forest Service Recreation Site
- boat or vehicle access
- four vehicle units

Hugh Keenleyside Dam Picnic/View Point Area
- picnic area

Downstream Area

The Columbia River downstream of the Hugh Keenleyside Dam represents the only section of the Columbia River in the West Kootenays that is free-flowing. It is considered to have moderate recreational capability (Era Business Consultants 1981). The river is mainly used for recreation by regional residents. Fishing, boating, swimming, sight-seeing, and picnicking are the major activities.

There are few developed facilities for outdoor recreation. The most important is Pass Creek Regional Park, which offers swimming, camping, and picnicking (Figure 3.17). This park is heavily used by regional residents. There is a baseball diamond on the river in north Castlegar, and, at Birchbank, a golf course and picnic area are owned by Cominco. Boats can be launched at a public ramp at Robson and two at Trail. Beyond these developed facilities there are informal river access points used by fishermen and several small neighbourhood parks.

The angling experience on the river is considered to be the best in a 300 mile area (S. Tait, Scotty's Marina, pers. comm., September 11, 1989). Walleye and sturgeon are important sport fish. Most angling is from the river banks. The river is becoming more important for boating as the number of boats coming up from the U.S. to the reservoir and local jet and drag boat use is increasing. Navigation can be difficult during low water periods (S. Tait, Scotty's Marina, pers. comm., September 11, 1989).

Facilities Inventory

Pass Creek Regional Park
- administered by Central Kootenay Regional District
- picnic facilities
- several man-made swimming ponds
- campground
- baseball diamond

Robson Boat Launch
- concrete boat launch ramp extending to low water

Castlegar Waterfront
- baseball diamond at north end of river
- Zuckerberg Island, city-owned and operated park with foot bridge, walking trails and a historical building

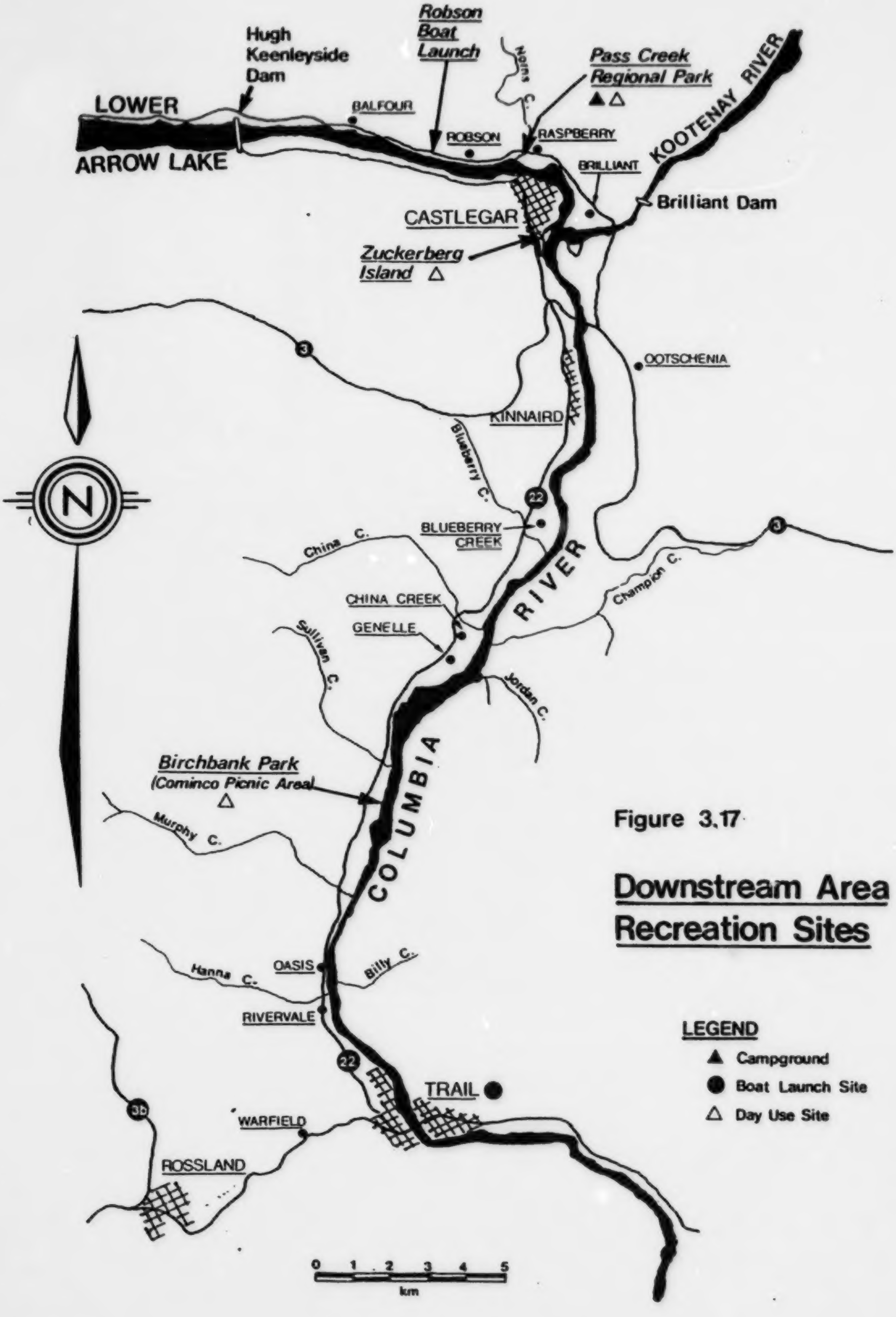

Robson
Boat
Launch
Hugh
Keenleyside
Dam
Norns C.
Pass Creek
Regional Park
▲△
LOWER
ARROW LAKE
BALFOUR
ROBSON
RASPBERRY
KOOTENAY RIVER
BRILLIANT
Brilliant Dam
CASTLEGAR
Zuckerberg
Island △
3
OOTSCHENIA
KINNAIRD
Blueberry C.
22
BLUEBERRY
CREEK
China C.
3
Champion C.
RIVER
CHINA CREEK
GENELLE
Sullivan C.
Jordan C.
Birchbank Park
(Cominco Picnic Area)
△
Murphy C.
COLUMBIA
OASIS
Hanna C.
Billy C.
RIVERVALE
22
TRAIL ●
3b
WARFIELD
ROSSLAND
0 1 2 3 4 5
km
N
LEGEND
▲ Campground
● Boat Launch Site
△ Day Use Site

Figure 3.17

Downstream Area Recreation Sites

Trail Boat Launch

- two boat launch ramps, concrete with gravel extending to low water

Birchbank Park

- picnic area
- golf course

4.0 IMPACT ASSESSMENT

4.1 Introduction

The intent of a new agreement for use of non-treaty storage behind Mica Dam is to optimize power generation over the whole length of the Columbia River within licence and power transmission constraints. Therefore, as noted in Section 1.0, it is proposed to use an additional 3.71×10^9 m^3 (3.0 MAF) of non-treaty storage behind Mica Dam, over and above the 2.47×10^9 m^3 (2.0 MAF) of non-treaty storage presently used for power generation. This water can be used to generate additional hydroelectric energy at both Mica and Revelstoke Dam generation facilities as well as at U.S. facilities along the Columbia River.

The purpose of this impact assessment is to estimate the environmental impacts on resources and resource uses in and around Mica and Arrow Lakes Reservoirs. As the Revelstoke Canyon power project is operated as a run-of-river plant and no changes to its operation are contemplated under the proposed Non-Treaty Storage Agreement, it was not considered in this assessment. Also, as the Revelstoke Reservoir extends almost to the base of Mica Dam, the small reach of the Columbia River below Mica Dam has not been considered in detail. However, the river system downstream of Hugh Keenleyside Dam has been considered in detail.

The impact assessment has been conducted within an ecological framework. Changes in the physical environment have been estimated based on physical data on reservoir operations provided by BCHPA, in conjunction with BPA. The effects of these changes on users of the aquatic environment, including fish and wildlife and their food sources, and man's uses of the reservoir have been analyzed. These latter effects include use for both recreation and industry (mainly forestry). Where possible, these effects are estimated quantitatively. However, limited knowledge of the present size and/or degree of use of environmental resources within the region may preclude a quantitative analysis. In these cases, a qualitative analysis is presented.

As noted in Section 1.2.2, the physical data consisted of statistical distributions of monthly reservoir elevations and outflows from Mica and Arrow Lakes Reservoirs. Data were supplied in semi-monthly formats for April and August as the reservoirs reach minimum and maximum levels during these months, respectively, and data on potential changes in the timing of reaching these levels were required.

As noted, the data were generated by BPA's System Analysis Model (SAM), which provides a stochastic simulation of reservoir levels and outflows using 200 different combinations of inflow hydrology for each year over a 20 year period (1989 to 2008), and alternative energy production and marketing scenarios. The operating regimes are described in Section 1.3. The comparisons made in the impact assessment are presented in Table 1.1.

Data for each regime were supplied by BCHPA on magnetic tape. The data represent a statistical time series of possible outcomes for each regime in response to changes in both operating conditions and variations in hydrological conditions over the twenty year period. The median and average data are listed in Tables 4.1 to 4.4 for each respective regime. Also indicated are the high and low values for reservoir elevations and outflows over the 20 year study period. These data are reported in feet (reservoir elevations) and cubic feet per second (reservoir outflows) in the tables, as this was the form of the data when it was supplied to Triton. Metric equivalents have, however, been used in the test. Detailed summary tables and hydrographs of median conditions for the regimes and their associated base cases are presented in Appendices 4, 5, and 6. Detailed flow and reservoir elevation data (in summary hydrograph format) for each regime and base case considered are presented in Appendices 7, 8 and 9. These represent the full range of possible elevations that could be experienced in Mica and Arrow Reservoirs and possible outflows from these reservoirs in response to differing (minimum -100% exceedance to maximum - 0% exceedance) possible combinations of hydrology, and the various operating strategies for the period 1989 to 2008.

As with any statistical representation of possible outcomes, the average case can be closely represented by the median (50% exceedance) values. The impact assessment is thus based mainly on the median values for the simulations. However, extreme minimum and maximum values have also been considered because, although these conditions will occur infrequently, resulting impacts may be greater.

TABLE 4.1 COMPARISON BETWEEN REGIME 1 AND BASE CASE, MEDIUM LOAD

MICA ELEVATIONS, REGIME 1

	HIGH	LOW	AVG
SEP	2468.1	2435.8	2451.9
OCT	2460.0	2429.8	2446.1
NOV	2448.7	2424.3	2438.6
DEC	2431.3	2410.8	2424.0
JAN	2417.6	2392.7	2407.9
FEB	2413.0	2378.8	2396.0
MAR	2403.9	2363.0	2383.5
AP1	2400.0	2354.5	2376.3
AP2	2399.9	2353.8	2376.7
MAY	2413.2	2378.2	2396.1
JUN	2443.3	2414.6	2429.6
JUL	2470.8	2439.5	2455.1
AG1	2471.8	2443.6	2457.8
AG2	2472.0	2443.6	2458.1
AVG	2436.7	2404.5	2421.3
HIGH	2472.0	2443.6	2458.1
LOW	2399.9	2353.8	2376.3

MICA ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	2475.0	2455.6	2472.3
OCT	2473.1	2453.6	2469.5
NOV	2469.7	2447.5	2465.0
DEC	2459.1	2428.6	2451.7
JAN	2444.4	2417.6	2437.8
FEB	2431.1	2412.2	2426.1
MAR	2417.0	2398.8	2412.6
AP1	2410.0	2392.6	2406.0
AP2	2410.2	2394.1	2405.9
MAY	2424.4	2410.5	2419.5
JUN	2451.4	2441.0	2447.7
JUL	2471.8	2466.9	2470.1
AG1	2473.9	2470.7	2473.3
AG2	2475.0	2471.9	2474.4
AVG	2449.0	2433.0	2445.1
HIGH	2475.0	2471.9	2474.4
LOW	2410.0	2392.6	2405.9

ARROW ELEVATIONS, REGIME 1

	HIGH	LOW	AVG
SEP	1444.0	1444.0	1444.0
OCT	1442.1	1441.9	1441.9
NOV	1442.1	1438.1	1440.8
DEC	1436.2	1431.8	1435.4
JAN	1414.4	1406.6	1411.2
FEB	1407.6	1396.8	1402.6
MAR	1399.9	1392.7	1399.2
AP1	1400.7	1398.7	1399.9
AP2	1403.9	1399.9	1402.1
MAY	1417.9	1414.6	1415.2
JUN	1437.5	1435.3	1436.4
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1427.0	1423.7	1425.8
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1392.7	1399.2

ARROW ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	1444.0	1443.5	1443.8
OCT	1441.9	1440.5	1441.6
NOV	1442.1	1438.1	1440.4
DEC	1436.2	1431.7	1435.3
JAN	1413.8	1406.6	1410.8
FEB	1406.7	1396.8	1401.9
MAR	1399.9	1396.2	1399.3
AP1	1399.9	1399.5	1399.9
AP2	1403.9	1399.9	1401.4
MAY	1415.3	1413.0	1414.9
JUN	1437.5	1435.3	1436.1
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1426.7	1423.8	1425.5
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1396.2	1399.3

MICA FLOWS, REGIME 1

	HIGH	LOW	AVG
SEP	33291	20518	30849
OCT	24320	14350	20470
NOV	23327	14270	17449
DEC	34000	22000	25645
JAN	27000	21036	26051
FEB	25000	10165	21666
MAR	22481	17000	19572
AP1	27000	15000	23547
AP2	18000	10000	10400
MAY	10000	10000	10000
JUN	10000	7239	9599
JUL	26304	20962	23681
AG1	40639	34000	35960
AG2	37089	32659	33830
AVG	25604	17800	22052
HIGH	40639	34000	35960
LOW	10000	7239	9599

MICA FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	30228	20518	22434
OCT	19996	14350	15770
NOV	19192	13061	15125
DEC	34000	22000	25673
JAN	27000	21036	26359
FEB	25000	10165	23647
MAR	23000	17000	21991
AP1	27000	15000	24750
AP2	18000	10000	10400
MAY	10000	10000	10000
JUN	10000	10000	10000
JUL	30960	21633	27541
AG1	40639	32576	33895
AG2	37706	31573	32719
AVG	25194	17779	21450
HIGH	40639	32576	33895
LOW	10000	10000	10000

ARROW FLOWS, REGIME 1

	HIGH	LOW	AVG
SEP	47692	34978	45595
OCT	40162	33279	36931
NOV	37171	25330	28862
DEC	51676	39515	43067
JAN	80428	68443	72801
FEB	50137	38068	46242
MAR	34436	28057	31783
AP1	29103	21155	25340
AP2	15980	10826	13014
MAY	29593	27325	28580
JUN	24663	16415	21010
JUL	52297	48638	50303
AG1	65172	57921	59886
AG2	55913	51749	53323
AVG	43887	35836	39767
HIGH	80428	68443	72801
LOW	15980	10826	13014

ARROW FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	45257	34726	37273
OCT	37105	31156	32862
NOV	32430	23021	26872
DEC	48282	40894	42866
JAN	79692	68900	74365
FEB	52529	38068	48588
MAR	37191	28057	33218
AP1	32870	22486	28822
AP2	19487	12796	17139
MAY	32838	27982	30557
JUN	24663	18166	21594
JUL	56134	48638	52427
AG1	65172	54459	57691
AG2	55492	51282	52299
AVG	44224	35759	39755
HIGH	79692	68900	74365
LOW	19487	12796	17139

TABLE 4.2 COMPARISON BETWEEN REGIME 1 AND BASE CASE, ARO

MICA ELEVATIONS, REGIME 1

	HIGH	LOW	AVG
SEP	2468.5	2436.1	2451.7
OCT	2461.1	2432.6	2447.0
NOV	2448.7	2426.2	2439.5
DEC	2432.5	2411.5	2424.6
JAN	2417.6	2392.6	2408.1
FEB	2412.2	2376.8	2395.6
MAR	2399.1	2362.7	2382.1
AP1	2396.4	2352.6	2375.1
AP2	2398.7	2353.0	2375.6
MAY	2410.1	2377.6	2395.3
JUN	2443.1	2412.6	2429.1
JUL	2470.8	2438.8	2454.5
AG1	2471.8	2442.1	2457.3
AG2	2472.0	2443.5	2457.6
AVG	2435.9	2404.2	2420.9
HIGH	2472.0	2443.5	2457.6
LOW	2396.4	2352.6	2375.1

MICA ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	2475.0	2455.6	2472.3
OCT	2473.1	2453.6	2469.8
NOV	2469.7	2447.5	2465.2
DEC	2459.1	2428.6	2451.6
JAN	2444.4	2417.6	2437.5
FEB	2431.1	2411.3	2425.9
MAR	2417.0	2398.8	2412.2
AP1	2410.0	2391.6	2405.7
AP2	2410.2	2393.3	2405.6
MAY	2424.4	2409.5	2419.3
JUN	2451.4	2441.0	2447.6
JUL	2471.8	2465.5	2470.0
AG1	2473.8	2470.0	2473.3
AG2	2475.0	2471.4	2474.4
AVG	2449.0	2432.5	2445.0
HIGH	2475.0	2471.4	2474.4
LOW	2410.0	2391.6	2405.6

ARROW ELEVATIONS, REGIME 1

	HIGH	LOW	AVG
SEP	1444.0	1443.8	1443.9
OCT	1441.9	1440.7	1441.7
NOV	1442.1	1438.1	1440.4
DEC	1436.2	1432.0	1435.4
JAN	1414.1	1405.9	1411.0
FEB	1407.1	1395.2	1402.2
MAR	1399.9	1394.6	1399.2
AP1	1400.7	1399.5	1399.9
AP2	1403.9	1399.9	1401.8
MAY	1416.3	1414.1	1415.1
JUN	1437.5	1435.3	1436.2
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1426.8	1423.7	1425.6
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1394.6	1399.2

ARROW ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	1444.0	1443.5	1443.8
OCT	1441.9	1440.4	1441.4
NOV	1442.1	1438.1	1440.3
DEC	1436.2	1431.9	1435.3
JAN	1413.8	1405.9	1410.7
FEB	1406.7	1396.5	1401.8
MAR	1399.9	1396.2	1399.3
AP1	1399.9	1399.5	1399.9
AP2	1403.9	1399.9	1401.5
MAY	1415.3	1413.0	1414.9
JUN	1437.4	1435.3	1436.2
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1426.7	1423.7	1425.5
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1396.2	1399.3

MICA FLOWS, REGIME 1

	HIGH	LOW	AVG
SEP	32815.0	20518.0	30292.6
OCT	23367.0	14350.0	19007.1
NOV	25805.0	14898.0	18535.2
DEC	34000.0	22000.0	26467.7
JAN	27000.0	21036.0	26118.6
FEB	25000.0	10165.0	22160.3
MAR	23000.0	17000.0	20057.3
AP1	27000.0	15000.0	22637.3
AP2	18000.0	10000.0	10400.0
MAY	10000.0	10000.0	10000.0
JUN	10000.0	5577.0	9503.0
JUL	26531.0	20317.0	23321.8
AG1	40000.0	33779.0	35734.5
AG2	37409.0	32957.0	33866.8
AVG	25709	17686	22007
HIGH	40000	33779	35735
LOW	10000	5577	9503

MICA FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	30389.0	20518.0	22406.5
OCT	19150.0	14350.0	15518.5
NOV	19466.0	13243.0	15348.2
DEC	34000.0	22000.0	25726.8
JAN	27000.0	21036.0	26353.5
FEB	25000.0	10165.0	23653.5
MAR	23000.0	17000.0	22000.0
AP1	27000.0	15000.0	24723.3
AP2	18000.0	10000.0	10400.0
MAY	10000.0	10000.0	10000.0
JUN	10000.0	10000.0	10000.0
JUL	30877.0	21633.0	27474.3
AG1	40639.0	32576.0	33790.8
AG2	37779.0	32037.0	32754.1
AVG	25164	17826	21439
HIGH	40639	32576	33791
LOW	10000	10000	10000

ARROW FLOWS, REGIME 1

	HIGH	LOW	AVG
SEP	47735.0	34978.0	45282.3
OCT	41497.0	33209.0	36250.6
NOV	37610.0	25589.0	29007.8
DEC	51533.0	40010.0	43449.9
JAN	81090.0	69417.0	73929.6
FEB	50548.0	38842.0	45987.1
MAR	34718.0	28559.0	31607.4
AP1	29249.0	21155.0	25381.0
AP2	16040.0	10439.0	12801.8
MAY	29571.0	27325.0	28379.0
JUN	24691.0	16733.0	21113.6
JUL	51596.0	47521.0	49990.3
AG1	65172.0	56677.0	59212.2
AG2	56019.0	51846.0	53755.4
AVG	44076	35879	39725
HIGH	81090	69417	73930
LOW	16040	10439	12802

ARROW FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	45675.0	34724.0	37337.8
OCT	36949.0	31142.0	32894.4
NOV	32537.0	23303.0	26896.4
DEC	48815.0	40836.0	42874.2
JAN	79658.0	68759.0	74334.6
FEB	52529.0	38842.0	48836.6
MAR	37088.0	28559.0	33228.9
AP1	32870.0	21470.0	28741.9
AP2	19487.0	12775.0	17156.4
MAY	32838.0	27982.0	30552.7
JUN	24766.0	18166.0	21540.1
JUL	55971.0	47521.0	52373.4
AG1	65172.0	54459.0	57611.0
AG2	55879.0	51282.0	52453.5
AVG	44302	35701	39774
HIGH	79658	68759	74335
LOW	19487	12775	17156

TABLE 4.3 COMPARISON BETWEEN REGIME 1 AND BASE CASE, AOS

MICA ELEVATIONS, REGIME 1

	HIGH	LOW	AVG
SEP	2464.6	2424.9	2439.6
OCT	2457.7	2421.7	2433.5
NOV	2447.5	2417.7	2426.1
DEC	2428.5	2404.2	2411.9
JAN	2412.7	2385.1	2394.9
FEB	2407.9	2366.5	2381.4
MAR	2395.6	2351.4	2365.7
AP1	2391.5	2342.2	2357.3
AP2	2391.2	2341.8	2358.0
MAY	2407.3	2365.6	2380.4
JUN	2440.7	2402.6	2416.4
JUL	2467.4	2430.8	2442.9
AG1	2468.1	2432.8	2445.4
AG2	2467.8	2431.4	2445.0
AVG	2432.0	2394.2	2407.0
HIGH	2468.1	2432.8	2445.4
LOW	2391.2	2341.8	2357.3

MICA ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	2475.0	2455.6	2471.4
OCT	2473.1	2453.6	2468.5
NOV	2469.7	2447.5	2463.8
DEC	2459.1	2428.5	2450.7
JAN	2444.4	2412.7	2436.5
FEB	2431.1	2407.9	2425.0
MAR	2417.0	2395.1	2411.4
AP1	2410.0	2388.7	2404.8
AP2	2410.2	2388.8	2404.5
MAY	2424.4	2407.1	2418.6
JUN	2451.4	2438.1	2446.9
JUL	2470.8	2462.7	2469.4
AG1	2473.6	2466.5	2472.5
AG2	2475.0	2467.8	2473.6
AVG	2448.9	2430.0	2444.1
HIGH	2475.0	2467.8	2473.6
LOW	2410.0	2388.7	2404.5

ARROW ELEVATIONS, REGIME 1

	HIGH	LOW	AVG
SEP	1444.0	1444.0	1444.0
OCT	1442.0	1441.9	1441.9
NOV	1442.1	1438.1	1440.8
DEC	1436.2	1432.0	1435.4
JAN	1414.6	1406.0	1411.2
FEB	1406.7	1396.4	1402.4
MAR	1399.9	1393.6	1399.3
AP1	1400.6	1398.7	1399.9
AP2	1403.9	1399.9	1402.0
MAY	1416.8	1413.4	1415.0
JUN	1437.5	1435.3	1436.3
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1426.9	1423.7	1425.7
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1393.6	1399.3

ARROW ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	1444.0	1443.5	1443.8
OCT	1441.9	1440.4	1441.5
NOV	1442.1	1438.1	1440.4
DEC	1436.2	1431.6	1435.3
JAN	1413.8	1406.2	1410.7
FEB	1406.7	1396.4	1401.9
MAR	1399.9	1395.9	1399.2
AP1	1399.9	1399.5	1399.9
AP2	1403.9	1399.9	1401.4
MAY	1415.3	1413.0	1414.9
JUN	1437.5	1435.3	1436.1
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1426.7	1423.7	1425.5
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1395.9	1399.2

MICA FLOWS, REGIME 1

	HIGH	LOW	AVG
SEP	32816	20838	30033
OCT	26319	14470	20722
NOV	25453	15016	18544
DEC	34000	22001	26631
JAN	28000	23000	26800
FEB	25000	9528	22145
MAR	23000	14917	19354
AP1	27000	15000	21951
AP2	18000	10000	10400
MAY	10000	10000	10000
JUN	10000	5481	9077
JUL	25760	19437	22443
AG1	40639	34000	36174
AG2	37779	32560	34413
AVG	25983	17589	22049
HIGH	40639	34000	36174
LOW	10000	5481	9077

MICA FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	32227	20518	22909
OCT	21410	14470	15997
NOV	18332	13061	15090
DEC	34000	22000	25600
JAN	28000	23000	26800
FEB	25000	9528	23377
MAR	23000	17000	21953
AP1	27000	15000	24710
AP2	18000	10000	10400
MAY	10000	10000	10000
JUN	10000	10000	10000
JUL	30960	21455	27380
AG1	41171	32434	34011
AG2	38249	31573	32839
AVG	25525	17860	21505
HIGH	41171	32434	34011
LOW	10000	9528	10000

ARROW FLOWS, REGIME 1

	HIGH	LOW	AVG
SEP	47735	34978	45298
OCT	43110	33627	37649
NOV	37852	25708	29463
DEC	51275	41734	43783
JAN	79546	69335	74655
FEB	48262	36846	44770
MAR	34824	28006	32017
AP1	28522	20381	25623
AP2	18639	9797	13377
MAY	29567	26397	27832
JUN	22546	15149	20710
JUL	52355	48349	50243
AG1	65162	58087	59978
AG2	56810	51905	53528
AVG	44015	35736	39923
HIGH	79546	69335	74655
LOW	18639	9797	13377

ARROW FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	47682	34726	37706
OCT	37899	31156	33066
NOV	32758	23021	26827
DEC	48765	40894	42733
JAN	79658	68900	74872
FEB	52529	36846	48310
MAR	37191	28006	32970
AP1	32870	22834	28706
AP2	19487	13235	17210
MAY	32838	27982	30449
JUN	24663	18166	21581
JUL	56134	48586	52419
AG1	65172	54459	57736
AG2	55982	51282	52414
AVG	44545	35721	39786
HIGH	79658	68900	74872
LOW	19487	13235	17210

TABLE 4.4 COMPARISION BETWEEN REGIME 2 AND BASE CASE, MEDIUM LOAD

MICA ELEVATIONS, REGIME 2

	HIGH	LOW	AVG
SEP	2470.7	2450.6	2458.6
OCT	2465.9	2448.6	2454.9
NOV	2458.2	2444.8	2449.7
DEC	2441.6	2432.7	2436.1
JAN	2427.9	2416.7	2421.5
FEB	2417.4	2403.6	2409.3
MAR	2405.3	2388.1	2395.2
AP1	2401.3	2380.4	2388.1
AP2	2401.1	2380.2	2387.9
MAY	2417.3	2400.1	2405.0
JUN	2444.8	2429.0	2435.3
JUL	2470.8	2451.6	2459.0
AG1	2472.5	2454.0	2461.5
AG2	2473.6	2454.2	2461.9
AVG	2440.6	2423.9	2430.3
HIGH	2473.6	2454.2	2461.9
LOW	2401.1	2380.2	2387.9

MICA ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	2475.0	2455.6	2472.3
OCT	2473.1	2453.6	2469.5
NOV	2469.7	2447.5	2465.0
DEC	2459.1	2428.6	2451.7
JAN	2444.4	2417.6	2437.8
FEB	2431.1	2412.2	2426.1
MAR	2417.0	2398.8	2412.6
AP1	2410.0	2392.6	2406.0
AP2	2410.2	2394.1	2405.9
MAY	2424.4	2410.5	2419.5
JUN	2451.4	2441.0	2447.7
JUL	2471.8	2466.9	2470.1
AG1	2473.9	2470.7	2473.3
AG2	2475.0	2471.9	2474.4
AVG	2449.0	2433.0	2445.1
HIGH	2475.0	2471.9	2474.4
LOW	2410.0	2392.6	2405.9

ARROW ELEVATIONS, REGIME 2

	HIGH	LOW	AVG
SEP	1444.0	1443.1	1443.8
OCT	1441.9	1438.8	1441.4
NOV	1441.9	1437.5	1439.7
DEC	1436.2	1431.5	1434.9
JAN	1413.3	1405.5	1410.2
FEB	1406.4	1396.1	1401.2
MAR	1399.9	1395.9	1399.4
AP1	1399.9	1399.5	1399.9
AP2	1403.9	1399.9	1401.9
MAY	1415.3	1413.1	1414.9
JUN	1437.5	1435.3	1436.4
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1426.6	1423.4	1425.4
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1395.9	1399.4

ARROW ELEVATIONS, BASE CASE

	HIGH	LOW	AVG
SEP	1444.0	1443.5	1443.8
OCT	1441.9	1440.5	1441.6
NOV	1442.1	1438.1	1440.4
DEC	1436.2	1431.7	1435.3
JAN	1413.8	1406.6	1410.8
FEB	1406.7	1396.8	1401.9
MAR	1399.9	1396.2	1399.3
AP1	1399.9	1399.5	1399.9
AP2	1403.9	1399.9	1401.4
MAY	1415.3	1413.0	1414.9
JUN	1437.5	1435.3	1436.1
JUL	1444.0	1444.0	1444.0
AG1	1444.0	1444.0	1444.0
AG2	1444.0	1444.0	1444.0
AVG	1426.7	1423.8	1425.5
HIGH	1444.0	1444.0	1444.0
LOW	1399.9	1396.2	1399.3

MICA FLOWS, REGIME 2

	HIGH	LOW	AVG
SEP	27432.0	13561.0	25786.8
OCT	19204.0	11650.0	17398.3
NOV	19052.0	13215.0	15408.3
DEC	33583.0	22000.0	26525.0
JAN	27000.0	22311.0	25855.2
FEB	25000.0	17657.0	23694.2
MAR	23000.0	17000.0	21588.9
AP1	27000.0	15000.0	24668.1
AP2	18000.0	10000.0	10400.0
MAY	10000.0	10000.0	10000.0
JUN	10000.0	10000.0	10000.0
JUL	28500.0	21184.0	25137.6
AG1	40000.0	33500.0	34903.6
AG2	37687.0	32037.0	33725.4
AVG	24676	17794	21792
HIGH	40000	33500	34904
LOW	10000	10000	10000

MICA FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	30228.0	20518.0	22433.7
OCT	19996.0	14350.0	15770.0
NOV	19192.0	13061.0	15124.9
DEC	34000.0	22000.0	25672.8
JAN	27000.0	21036.0	26359.3
FEB	25000.0	10165.0	23647.3
MAR	23000.0	17000.0	21990.6
AP1	27000.0	15000.0	24750.0
AP2	18000.0	10000.0	10400.0
MAY	10000.0	10000.0	10000.0
JUN	10000.0	10000.0	10000.0
JUL	30960.0	21633.0	27540.7
AG1	40639.0	32576.0	33895.4
AG2	37706.0	31573.0	32719.1
AVG	25194	17779	21450
HIGH	40639	32576	33895
LOW	10000	10000	10000

ARROW FLOWS, REGIME 2

	HIGH	LOW	AVG
SEP	42616.0	30467.0	40837.9
OCT	35987.0	32744.0	34900.7
NOV	35096.0	24040.0	27645.8
DEC	50856.0	40305.0	43506.8
JAN	80174.0	68862.0	74545.1
FEB	50171.0	41785.0	45748.3
MAR	35371.0	26835.0	31947.7
AP1	32870.0	22337.0	28975.5
AP2	19192.0	15117.0	17111.8
MAY	29571.0	27446.0	28745.0
JUN	26926.0	19097.0	23510.0
JUL	53890.0	48717.0	50795.9
AG1	65172.0	55457.0	58355.5
AG2	55492.0	52323.0	53793.3
AVG	43813	36109	40030
HIGH	80174	68862	74545
LOW	19192	15117	17112

ARROW FLOWS, BASE CASE

	HIGH	LOW	AVG
SEP	45257.0	34726.0	37272.5
OCT	37105.0	31156.0	32861.7
NOV	32430.0	23021.0	26871.5
DEC	48282.0	40894.0	42866.0
JAN	79692.0	68900.0	74365.0
FEB	52529.0	38068.0	48587.6
MAR	37191.0	28057.0	33218.2
AP1	32870.0	22486.0	28822.0
AP2	19487.0	12796.0	17138.6
MAY	32838.0	27982.0	30557.4
JUN	24663.0	18166.0	21594.3
JUL	56134.0	48638.0	52427.3
AG1	65172.0	54459.0	57691.3
AG2	55492.0	51282.0	52299.4
AVG	44224	35759	39755
HIGH	79692	68900	74365
LOW	19487	12796	17139

The median data are presented in Appendix 4, Table A4.1.1 for the Base Case (medium load) for Mica Reservoir. These data show a 21 to 24 m (67.5 to 79.3 ft) annual range in reservoir elevation with annual elevations between 741.9 and 745.2 m (2434 and 2445 ft) until 1994, when the current Non-Treaty Storage Agreement expires. A much more regular range and annual reservoir level of 19.8 to 21.6 m (65.0 to 72.2 ft) and 745.9 to 746.7 m (2447 to 2449 ft), respectively, will be implemented after 1993 if no new agreement is negotiated. The averages of these data for the whole period (1989-2008) are presented in Figure A4.1.1 in Appendix 4.

Outflows from Mica Reservoir for the Base Case (medium load) peak in August and are lowest in May and June (Appendix 4, Table A4.1.2). The lowest monthly outflow in each year is 283 m³/s (10,000 ft³/s) with highest monthly flows of up to 1150 m³/s (40,640 ft³/s) (Appendix 4, Figure A4.1.2). However, highest monthly flows are fairly uniform at about 934 m³/s (33,000 ft³/s) from 1993 on.

Elevations in Arrow Lakes Reservoir for the Base Case (medium load) peak each year at 440 m (1444 ft) in July and August (Appendix 4, Figure A4.1.3). Lowest elevations occur between February and April and average about 427 m (1400 ft) (Appendix 4, Table A4.1.3).

Outflows from the Arrow Lakes Reservoir peak in January, with a secondary peak in August (Appendix 4, Figure A4.1.4). Annual outflow is about 1130 m³/s (40,000 ft³/s) in all years (Appendix 4, Table A4.1.4). Lowest outflows average 485 m³/s (17,140 ft³/s), while highest outflows average 2105 m³/s (74,365 ft³/s).

4.2 Physical Effects

4.2.1 Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Mica Elevations

The proposed new Non-Treaty Storage Agreement would increase the use of non-treaty storage behind Mica Dam from 2.47 x 10^9 m³ to 6.18 x 10^9 m³ (2.0 MAF to 5.0 MAF), a 150% increase. Consistent with this increase, with Regime 1 (medium load), the average elevation of the Mica Reservoir decreases during all times of year, and the annual operating range increases by up to 6.4 m (21 ft) compared to the Base Case (medium load). The greatest changes occur during the months of October through April. With Regime 1, annual reservoir elevations fluctuate between 724.3 and 749.2 m (2376.3 and 2458.1 ft) with an operating range of 21.7 to 28.4 m (71 to 93 ft) (Appendix 4, Table A4.2.1). Differences between Regime 1 and Base Case annual elevations range from no change to a 12.5 m (41 ft) decrease with Regime 1 (Appendix 4, Table A4.3.1). The average difference in reservoir elevation is presented in Figure 4.1 (4.1.1). Under Regime 1, the lowest monthly water levels throughout the year occur in the 1994, 1995 and 1996 study years (Appendix 4, Table A4.2.1). Maximum elevations at Mica would remain near full pool but would be achieved less frequently. Minimum elevations would drop from 723.9 m (2375 ft) to 707.1 m (2320 ft) with Regime 1 (medium load) compared to the Base Case (medium load).

Mica Outflows

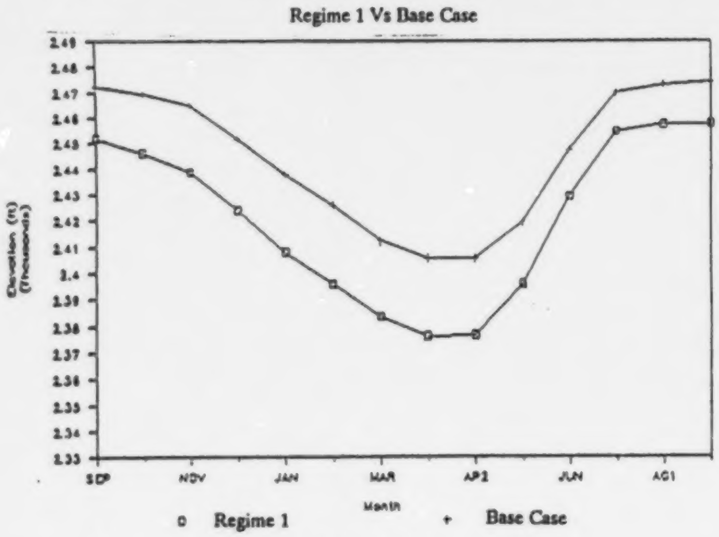
Under Regime 1 (medium load) operating conditions, average outflows generally increase in August through November, and decrease in December through July, compared to the Base Case (medium load) (Figure 4.1 (4.1.2); also, Appendix 4, Figure A4.3.2). With Regime 1, the highest average flow increase (238.3 m^3/s (8415 ft^3/s)) occurs during September, while the highest average flow reduction (109 m^3/s (3859 ft^3/s)) occurs in July (Appendix 4, Table A4.3.2), compared to the Base Case. Over the 20 year study period, Regime 1 annual average flows are approximately 595 m^3/s (21,000 ft^3/s). The lowest average flow (283 m^3/s (10,000 ft^3/s)) occurs in May, while the highest average flow (1018 m^3/s (35,960 ft^3/s)) occurs in August (similar to the Base Case). The highest and lowest flows for Regime 1 over the period of study are 1150.8 m^3/s (40,639 ft^3/s) and 205.0 m^3/s (7239 ft^3/s), respectively, and occur in the 1992 and 1993 study years (Appendix 4, Table A4.2.2). Changes in maximum and minimum flows would be small.

Arrow Elevations

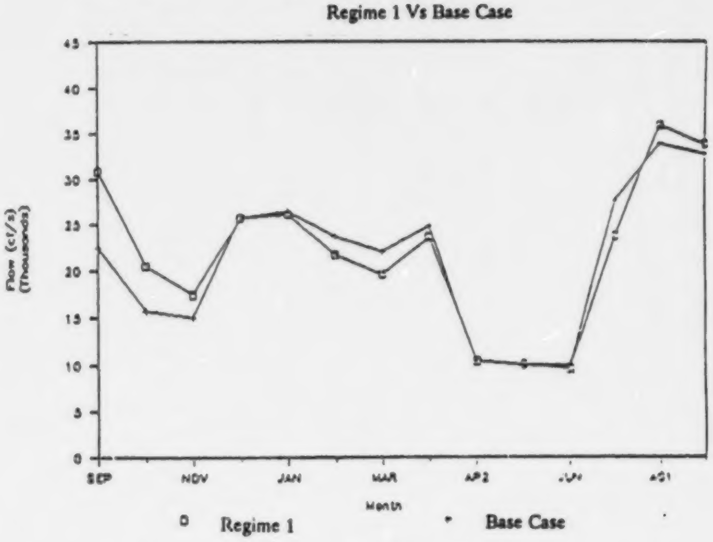
Monthly and annual reservoir elevations for the Arrow Lakes Reservoir are presented in Appendix 4, Table A4.2.3. Differences between Regime 1 and Base Case average elevations are provided in Appendix 4, Table A4.3.3 and illustrated graphically in Appendix 4, Figure A4.3.3. The annual average elevation difference between Regime 1

Figure 4.1 Average Reservoir Elevations and Outflows - Regime 1 (Medium Loads) Versus Base Case (Medium Loads)

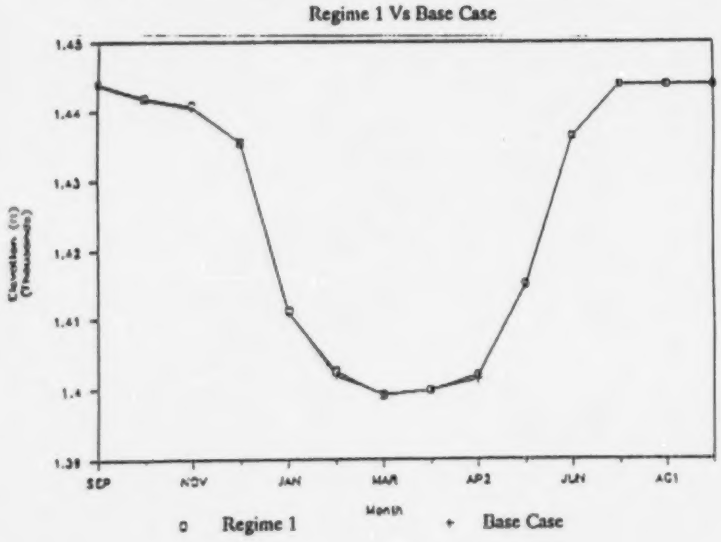
4.1.1 Elevations at Mica, MED



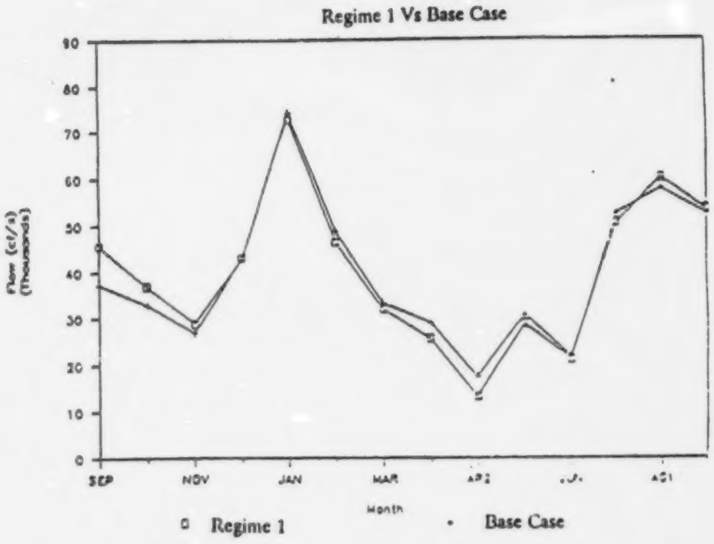
4.1.2 Flows at Mica, MED



4.1.3 Elevations at Arrow, MED



4.1.4 Flows at Arrow, MED



(medium load) and the Base Case (medium load) is 0.07 m (0.3 ft), ranging from a decrease of 0.03 m (0.1 ft) in March, to an increase of 0.2 m (0.7 ft) in early April (Figure 4.1 (4.1.3); also, Appendix 4, Table A4.3.3). The highest and lowest average elevations with Regime 1 are 440.1 m (1444 ft) (full pool) and 426.5 m (1399.2 ft), occurring in the months of July through September and March, respectively. The highest average elevation of 440.1 m (1444 ft) occurs in all years and the lowest average elevation of 424.5 m (1392.7 ft) occurs in the 1990 study year (Appendix 4, Table A4.2.3). Changes in maximum and minimum elevations would be small.

Arrow Outflows

Under Regime 1 (medium load), average outflows (Appendix 4, Figure A4.3.4) increase in August through December and decrease January through July compared to Base Case (medium load) outflows (Figure 4.1 (4.1.4)). With Regime 1, the highest average flow increase (235.7 m³/s (8322.1 ft³/s)) occurs in September, while the highest average flow reduction (116.8 m³/s (4124.5 ft³/s)) occurs in April (Appendix 4, Table A4.3.4), compared to the Base Case flows. Over the period of study, Regime 1 annual flows average approximately 1135 m³/s (40,080 ft³/s). The lowest average flow (368.5 m³/s (13,014 ft³/s)) occurs in late April, while the highest average flow (2061.5 m³/s (72,801 ft³/s)) occurs in January (Appendix 4, Table A4.2.4). The highest and lowest average flows are 2277.5 m³/s (80,428 ft³/s) and 306.6 m³/s (10,826 ft³/s), respectively, and occur in the 1993 and 1995 study years (Appendix 4, Table A4.2.4). Minimum outflows would not change but maximum flows increase from 2775 m³/s (98,000 ft³/s) to 3115 m³/s (110,000 ft³/s) with Regime 1 compared to the Base Case (medium loads).

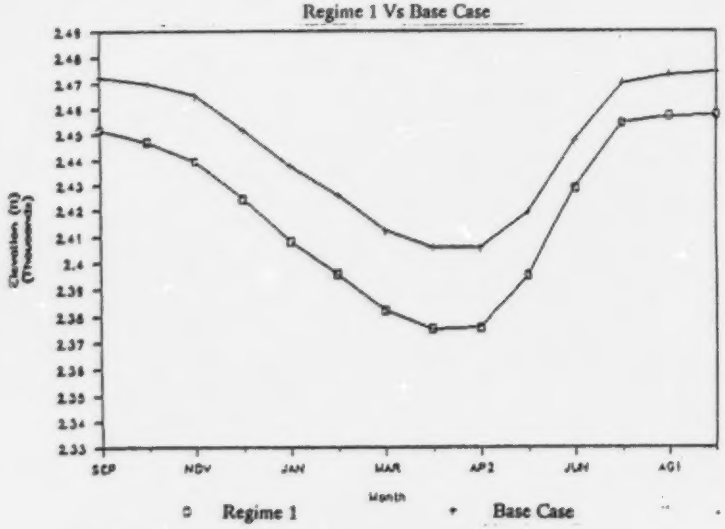
4.2.2 Regime 1 (ARO) Compared to Base Case (ARO)

Mica Elevations

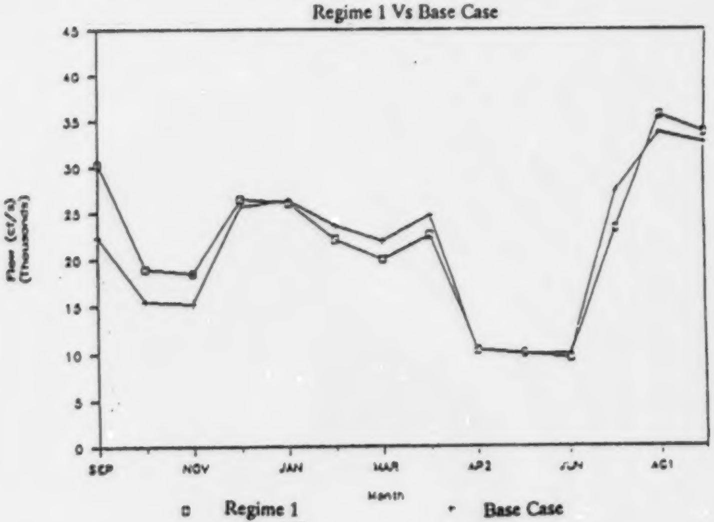
Under Regime 1 (ARO), the average elevation of the Mica Reservoir decreases, and its annual range increases by up to 6.7 m (22 ft) compared to the Base Case (ARO) (Figure 4.2 (4.2.1)). These changes are very similar to those which occur under Regime 1 (medium load) compared to Base Case (medium load). With Regime 1 (ARO), annual reservoir elevations fluctuate between 733.3 and 742.1 m (2405.9 and 2434.6 ft) with an operating

Figure 4.2 Average Reservoir Elevations and Outflows - Regime 1 (ARO) Versus Base Case (ARO)

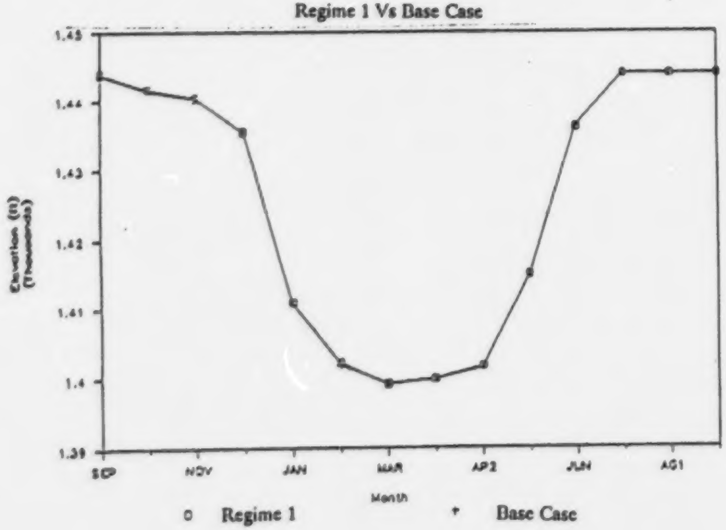
4.2.1 Elevations at Mica, ARO



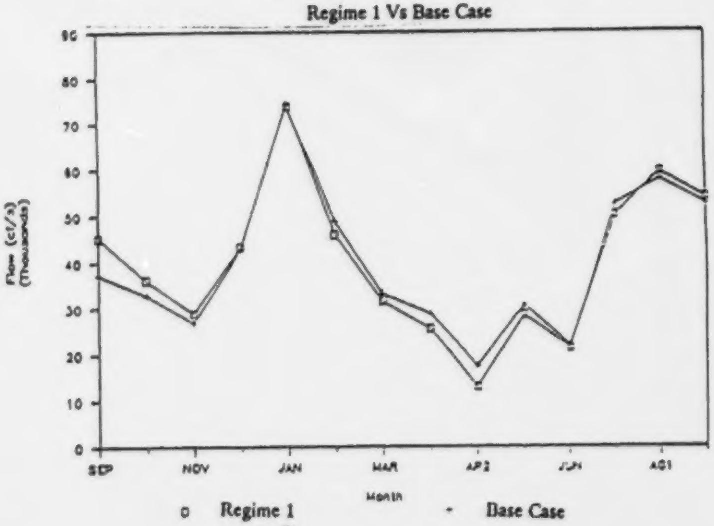
4.2.2 Flows at Mica, ARO



4.2.3 Elevations at Arrow, ARO



4.2.4 Flows at Arrow, ARO



range of 22.8 to 28.2 m (74.8 to 92.5 ft) (Appendix 5, Table A5.2.1). Differences in annual elevations range from no change to a 12.6 m (41.3 ft) decrease being, on average, lower during all times of the year when compared to the Base Case (ARO) (Appendix 5, Table A5.3.1). The greatest changes in average monthly median elevation occur during the months of September through April (Appendix 5, Figure A5.3.1). The lowest Regime 1 (ARO) water levels throughout the year occur in the 1994, 1995 and 1996 study years (Appendix 5, Table A5.2.1). As with Regime 1 (medium load), maximum elevations would remain near full pool while minimum elevations would drop from 723.9 m (2375 ft) to 707.1 m (2320 ft) with Regime 1 (ARO) compared to the Base Case (ARO).

Mica Outflows

Average outflows generally increase in August through December, and decrease in January through July with Regime 1 (ARO) compared to the Base Case (ARO) (Figure 4.2 (4.2.2); also, Appendix 5, Figure A5.3.2). With Regime 1 (ARO), the highest flow increase (223.3 m^3/s (7886 ft^3/s)) occurs during September, while the highest average flow reduction (117.6 m^3/s (4152.4 ft^3/s)) occurs in July compared to the Base Case (ARO) (Appendix 5, Table A5.3.2).

Over the period of study, Regime 1 (ARO) annual average flows are approximately 606 m^3/s (21,400 ft^3/s). The lowest average flow (269.1 m^3/s (9503 ft^3/s)) occurs in June, while the highest average flow (1012 m^3/s (35,734.5 ft^3/s)) occur in August. Regime 1 (ARO) highest and lowest average flows for the period of study are 1132.7 m^3/s (40,000 ft^3/s) and 157.9 m^3/s (5577 ft^3/s), respectively, and occur in the 1992 and 1993 study years (Appendix 5, Table A5.2.2). Differences in maximum and minimum flows would be small.

Arrow Elevations

Monthly and annual average reservoir elevations under Regime 1 (ARO) are presented in Appendix 5, Table A5.2.3. Differences between Regime 1 (ARO) and Base Case (ARO) average elevations are given in Appendix 5, Table A5.3.3 and illustrated graphically in Appendix 5, Figure A5.3.3. The annual average elevation difference between Regime 1 (ARO) and the Base Case (ARO) is 0.03 m (0.1 ft). Average changes in Regime 1 (ARO) elevations range from no change in March, and June through August, to a 0.12 m (0.4 ft) increase in late April, compared to the Base Case (ARO) (Figure 4.2 (4.2.3); also, Appendix 5, Table A5.3.3).

With Regime 1 (ARO), the highest and lowest average elevations are 440.1 m (1444 ft) (full pool) and 426.5 m (1399.2 ft), respectively, and occur in the months of July through August and March, respectively. Regime 1 highest and lowest average elevations of 440.1 m (1444 ft) and 425.1 m (1394.6 ft) occur in all years and the 1990 study year, respectively (Appendix 5, Table A5.2.3). No changes in maximum and minimum elevations will occur between Regime 1 (ARO) and the Base Case (ARO).

Arrow Outflows

With Regime 1 (ARO), average outflows generally increase in August through December and decrease in January through July, compared to the Base Case (ARO) (Figure 4.2 (4.2.4); also, Appendix 5, Figure A5.3.4). The highest average flow increase (225 m^3/s (7944.5 ft^3/s)) occurs in September, while the highest average flow reduction (123.3 m^3/s (4354.7 ft^3/s)) occurs in late April, compared to Base Case (ARO) flows (Appendix 5, Table A5.3.4).

Over the period of study, Regime 1 (ARO) annual flows average approximately 1134 m^3/s (40,048 ft^3/s). With Regime 1 (ARO), the lowest average flow (362.5 m^3/s (12,801.8 ft^3/s)) occurs in late April, while the highest average flow (2093.5 m^3/s (73,929.6 ft^3/s)) occurs in January. The highest and lowest flows are 2296.5 m^3/s (81,090 ft^3/s) and 295.6 m^3/s (10,439 ft^3/s), respectively, and occur in the 1993 and 1995 study years (Appendix 5, Table A5.2.4). Maximum and minimum flows would not change between Regime 1 (ARO) and the Base Case (ARO). With both, maximum flows will be up to 3442 m^3/s (118,000 ft^3/s).

4.2.3 Regime 1 (AOS) Compared to Base Case (AOS)

Mica Elevations

With Regime 1 (AOS), the average elevation of Mica Reservoir decreases and its annual operating range increases by up to 7.8 m (25.6 ft) when compared to the Base Case (AOS) and, on average, is lower during all times of the year. With Regime 1 (AOS), annual reservoir elevations fluctuate between 730.4 and 741 m (2396.2 and 2431.1 ft) with an operating range of 22.9 to 28.7 m (75.2 to 94.3 ft) (Figure 4.3 (4.3.1); also, Appendix 6, Table A6.2.1). The greatest changes in average elevation occur during the months of September through May (Appendix 6, Figure A6.3.1). Differences in annual operating levels range from no change to a 15.6 m (51.1 ft) decrease, which is the largest of any of the regimes studied (Appendix 6, Table A6.3.1). The lowest average monthly water levels throughout the year occur in the 1994, 1995 and 1997 study years (Appendix 6, Table A6.2.1). As with Regime 1 (medium load), maximum elevation would remain at 754.4 m (2475 ft) but the minimum elevation would decrease from 723.9 m (2375 ft) to 707.1 m (2320 ft) with Regime 1 (ARO) compared to the Base Case (ARO).

Mica Outflows

With Regime 1 (AOS), average outflows generally increase in August through December, and decrease in January through July, compared to Base Case (AOS) outflows (Figure 4.3 (4.3.2); also, Appendix 6, Figure A6.3.2). The highest average flow increase (201.7 m^3/s (7124.1 ft^3/s)) occurs during September, while the highest average flow reduction (139.8 m^3/s (4937.5 ft^3/s)) occurs in July, compared to the Base Case (AOS) (Appendix 6, Table A6.3.2).

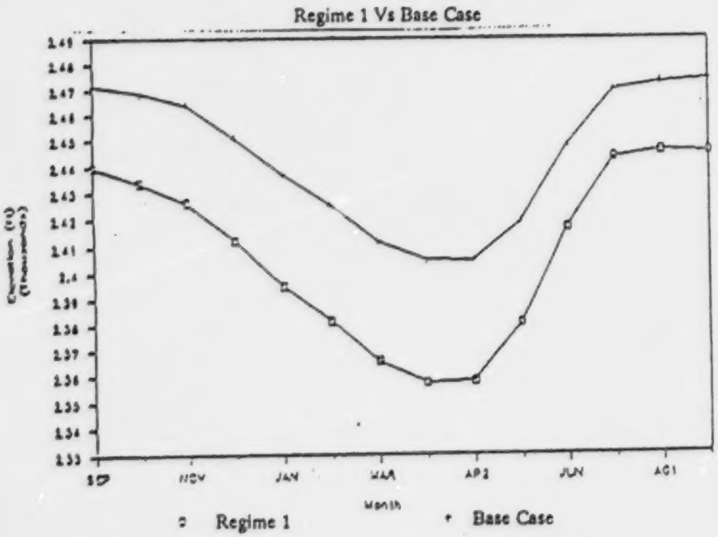
Over the period of study, Regime 1 (AOS) annual average flows are approximately 607 m^3/s (21,435 ft^3/s). The lowest average flow (257 m^3/s (9077 ft^3/s)) occurs in June, while the highest average flow (1024.3 m^3/s (36,173.6 ft^3/s)) occurs in August. The Regime 1 (AOS) highest and lowest average flows for the period of study are 1150.8 m^3/s (40,639 ft^3/s) and 155.2 m^3/s (5481 ft^3/s), respectively, and occur in the 1992 and 1998 study years (Appendix 6, Table A6.2.2). There would be little change in maximum or minimum outflows between Regime 1 (AOS) and the Base Case (AOS).

Arrow Elevations

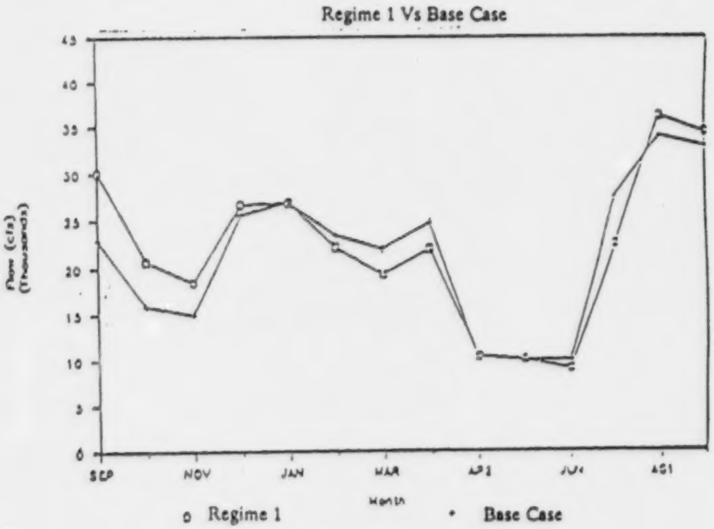
Monthly and annual average reservoir elevations under Regime 1 (AOS) are given in Appendix 6, Table A6.2.3. Differences between Regime 1 (AOS) and Base Case (AOS) average elevations are provided in Appendix 6, Table A6.3.3, and illustrated graphically in

Figure 4.3 Average Reservoir Elevations and Outflows - Regime 1 (AOS) Versus Base Case (AOS)

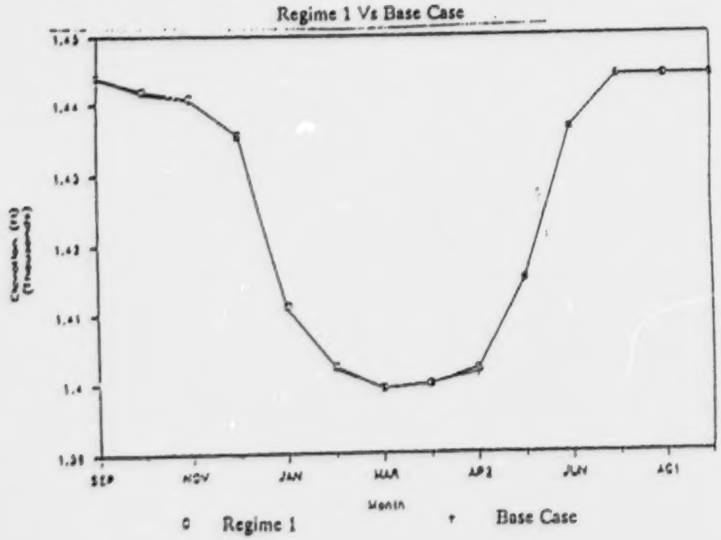
4.3.1 Elevations at Mica, AOS



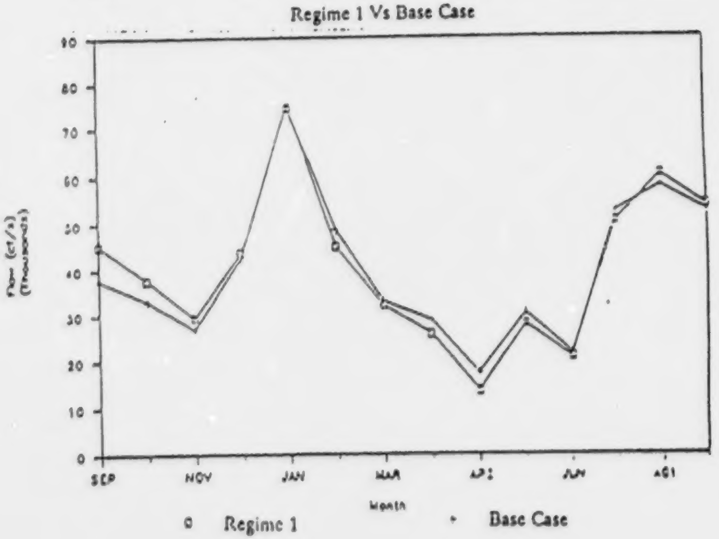
4.3.2 Flows at Mica, AOS



4.3.3 Elevations at Arrow, AOS



4.3.4 Flows at Arrow, AOS



Appendix 6, Figure A6.3.3. The annual average elevation difference between Regime 1 (AOS) and the Base Case (AOS) is 0.07 m (0.22 ft). Average changes in elevation range from no change in early April, July and August to a 0.18 m (0.6 ft) increase occurring in late April (Figure 4.3 (4.3.3); also, Appendix 6, Table A6.3.3).

With Regime 1 (AOS), the highest and lowest average elevations are 440.1 m (1444 ft) (full pool) and 426.5 m (1399.3 ft), respectively, and occur in the months of July through September, and March and April, respectively. The highest and lowest average elevations of 440.1 m (1444 ft) and 424.8 m (1393.6 ft) occur in the 1989 and 1990 study years, respectively (Appendix 6, Table A6.2.3). There would be no change in maximum or minimum elevations between Regime 1 (AOS) and the Base Case (AOS).

Arrow Outflows

Under Regime 1 (AOS) operating conditions, average outflows generally increase in August through December, and decrease in January through July, compared to the Base Case (AOS) (Figure 4.3 (4.3.4); also, Appendix 6, Figure A6.3.4). The highest average flow increase (215 m^3/s (7591.7 ft^3/s)) occurs in September, while the highest average flow reduction (108.5 m^3/s (3833.1 ft^3/s)) occurs in late April, compared to the Base Case (AOS) (Appendix 6, Table A6.3.4).

Over the period of study, Regime 1 (AOS) annual flows average approximately 1139 m^3/s (40,223 ft^3/s). The lowest average flow (378.8 m^3/s (13,377.3 ft^3/s)) occurs in late April, while the highest average flow (2114 m^3/s (74,654.8 ft^3/s)) occurs in January. The highest and lowest average flows are 2252.5 m^3/s (79,546 ft^3/s) and 277.4 m^3/s (9797 ft^3/s), respectively, and occur in the 1993 and 1995 study years (Appendix 6, Table A6.2.4). Minimum outflows would not change while maximum outflows would decrease approximately 283 m^3/s (10,000 ft^3/s) to 2832 m^3/s (100,000 ft^3/s) with Regime 1 (AOS) compared to the Base Case (AOS).

4.2.4 Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Mica Elevations

Under Regime 2 (medium load), the annual elevation of the Mica Reservoir decreases at all times of the year, and the annual operating range increases by up to 3.4 m (11.1 ft) compared to the Base Case (medium load) (Figure 4.4 (4.4.1)). These changes are smaller than under Regime 1 (medium load). With Regime 2, annual reservoir elevations fluctuate between 739.5 and 744.0 m (2426.1 and 2440.9 ft) with an annual range of 21.2 to 23.6 m (69.7 to 77.5 ft) (Appendix 4, Table A4.4.1). Over the period of study, average differences between Regime 2 and Base Case annual elevations range from a 1.0 m (3.2 ft) increase to a 7.0 m (22.9 ft) decrease (Appendix 4, Table A4.5.1). The greatest changes in average elevation would occur during the months of September through April (Appendix 4, Figure A4.5.1). With Regime 2, the lowest water levels occur in the 1995, 2002 and 2003 study years (Appendix 4, Table A4.4.1). Maximum elevations would not change. However, minimum elevations would decrease from 723.9 m (2375 ft) to 707.1 m (2320 ft) with Regime 2 compared to the Base Case (medium loads).

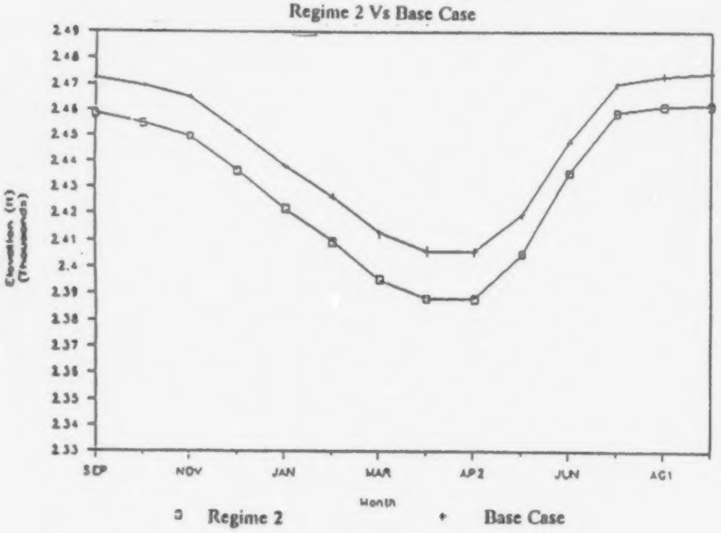
Mica Outflows

Under Regime 2 (medium load) operating conditions, average outflows generally increase in August through December, and decrease in January through July, compared to Base Case (medium load) outflows (Figure 4.4 (4.4.2); also, Appendix 4, Figure A4.5.2). The highest average flow increase (95.0 m^3/s (3353 ft^3/s)) occurs during September, while the highest average flow reduction (68.1 m^3/s (2403 ft^3/s)) occurs in July, compared to Base Case flows (Appendix 4, Table A4.5.2).

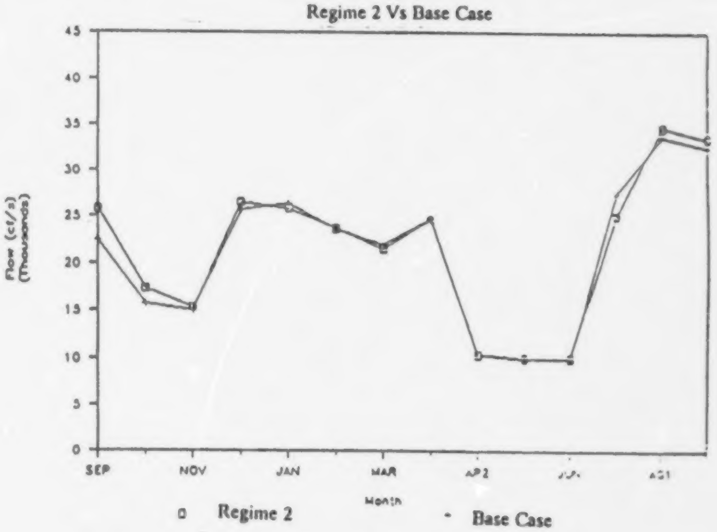
Over the period of study, Regime 2 annual average flows are approximately 598 m^3/s (21,104 ft^3/s). With Regime 2, the lowest average flow (283 m^3/s (10,000 ft^3/s)) occurs in late April, May and June (similar to the Base Case), while the highest average flow (988.4 m^3/s (34,903.6 ft^3/s)) occurs in August. The highest and lowest average flows for the period of study are 1132.7 m^3/s (40,000 ft^3/s) and 283 m^3/s (10,000 ft^3/s), respectively, and occur in the 1992 and all study years, respectively (Appendix 4, Table A4.4.2). Changes in maximum and minimum flows would be small.

Figure 4.4 Average Reservoir Elevations and Outflows - Regime 2 (Medium Loads) Versus Base Case (Medium Loads)

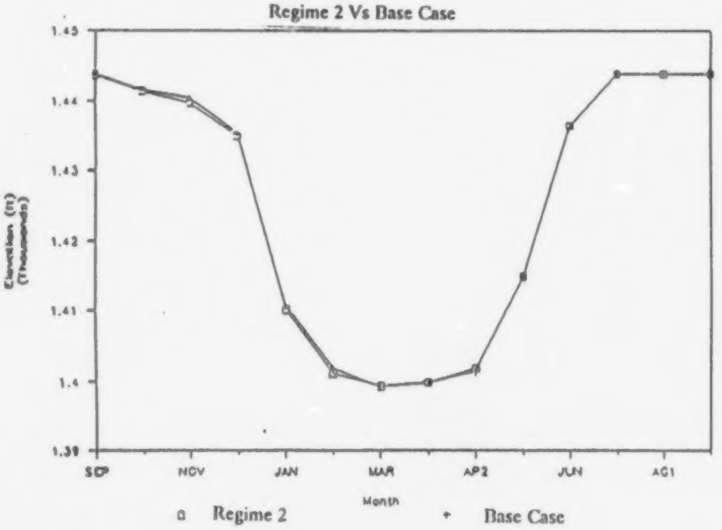
4.4.1 Elevations at Mica, MED



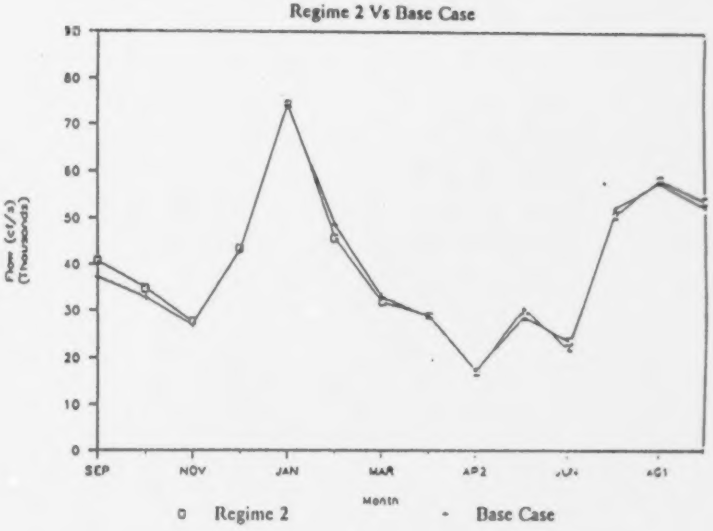
4.4.2 Flows at Mica, MED



4.4.3 Elevations at Arrow, MED



4.4.4 Flows at Arrow, MED



Arrow Elevations

Monthly and annual reservoir elevations for Regime 2 are presented in Appendix 4, Table A4.4.3. Differences between Regime 2 and Base Case average elevations are presented in Appendix 4, Table A4.5.3 and illustrated graphically in Appendix 4, Figure A4.5.3. The annual average elevation of the reservoir with Regime 2 (medium load) compared to the Base Case (medium load) decreases by 0.03 m (0.1 ft). Average changes in elevation range from a 0.2 m (0.7 ft) decrease in February, to a 0.15 m (0.5 ft) increase in late April (Figure 4.4 (4.4.3); also, Appendix 4, Table A4.5.3).

With Regime 2, the highest and lowest average elevations are 440.1 m (1444 ft) (full pool) and 426.5 m (1399.4 ft), respectively, and occur in the months of July through August, and March, respectively. The highest and lowest average elevations of 440.1 m (1444 ft) and 426.5 m (1395.9 ft) occur in all years and the 1992 study year, respectively (Appendix 4, Table A4.4.3). Maximum and minimum reservoir elevations would not change between Regime 2 and the Base Case.

Arrow Outflows

With Regime 2 (medium load), average outflows generally increase in August through January, early April and June, and decrease in February, March, late April and May, compared to Base Case (medium load) outflows (Figure 4.4 (4.4.4); also, Appendix 4, Figure A4.5.4). Under Regime 2, the highest average flow increase (101.0 m^3/s (3565.4 ft^3/s)) occurs in September, while the highest average flow reduction (80.4 m^3/s (2839.4 ft^3/s)) occurs in February (Appendix 4, Table A4.5.4).

Over the period of study, Regime 2 annual flows average approximately 1136 m^3/s (40,108 ft^3/s). With Regime 2, the lowest average flow (484.6 m^3/s (17,111.8 ft^3/s)) occurs in late April, while the highest average flow (2110.9 m^3/s (74,545.1 ft^3/s)) occurs in January. The highest and lowest flows are 2270.3 m^3/s (80,174 ft^3/s) and 428.1 m^3/s (15,117 ft^3/s), respectively, which occur in the 1993 and 2003 study years, respectively (Appendix 4, Table A4.4.4). Changes in maximum and minimum outflows would be small.

4.3 Biological Effects

4.3.1 Water Quality

The only area where water quality is a concern at present is the reach of the Columbia River downstream of Hugh Keenleyside Dam, due mainly to the effects of the Celgar pulp mill effluent.

Recent legislation has been introduced which requires pulp mills in B.C. to comply with the guidelines for effluent toxicity and effects on water quality outlined in the B.C. Waste Management Act. By 1991, all mills will be required to have secondary effluent treatment capability and reduced emissions of absorbable organic halogens, which are implicated in the production of dioxin-related compounds in the aquatic environment. Accordingly, future water quality in the vicinity of the Celgar pulp mill near Castlegar will be improved compared to what it is today. In general, water quality will be improved under all flow regimes by the required work on the pulp mill effluent treatment system.

4.3.2 Fish and Fish Habitat

Mica Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

The Base Case (medium load) median data indicate that the annual average reservoir level prior to the expiry of the current Columbia River Non-Treaty Storage Agreement will fluctuate between elevations 748.8 m and 751.5 m (2433.9 ft and 2442.4 ft) with an annual range in elevation of 20.8 to 24.4 m (67.5 to 79.3 ft). Subsequently, a slight decrease in the use of live storage is forecast for the period 1994 - 2008. The annual average reservoir elevation during this period would fluctuate between 752.2 and 753.3 m (2449.8 to 2444.7 ft) with an annual range of 20.0 to 22.2 m (65.0 to 72.2 ft).

Regime 1 (medium load) will result in a large reduction in the average annual elevation of Mica Reservoir over the 20 year study period compared to the Base Case. The annual range over which the water level fluctuates will increase substantially from between 20 to

24 m (66 to 79 ft) to between 21.7 to 28.4 m (71 to 93 ft). The Regime 1 (medium load) SAM data indicate that that portion of the current drawdown zone between full pool and 5 m (16 ft) below full pool will be flooded less frequently than under Base Case conditions. Also, outflows from the reservoir during drawdown periods will increase during the months of August through November and decrease during December through July compared to the Base Case.

Reproduction success of fish that spawn near shore in lakes and reservoirs is influenced by changes in water level. Adverse effects on reproduction in reservoirs are related to loss or dessication of habitat by drawdown. However, there are only a few isolated locations where shallow littoral habitat, which might prove suitable for spawning, exist, and these locations are currently exposed to the adverse effects of drawdown. Therefore, the reservoir's near shore habitat is not conducive to shoreline spawning. This would not change with Regime 1.

Because the drawdown zone of Mica Reservoir is barren, it does not provide productive fish rearing habitat. Therefore, over the short term, it is unlikely that reduced overall reservoir elevations associated with Regime 1 (compared to the Base Case) will have either a positive or negative effect on the amount of available rearing or spawning habitat both within the reservoir and its tributaries. However, over the long term, the lack of flooding of the drawdown zone within 5 m (16 ft) of full pool could lead to revegetation of newly exposed tributary shorelines and scouring of old stream channels such that new rearing and spawning habitat could be created in the vicinity of the confluences of the tributaries and the reservoir. This would not occur under Base Case operating conditions.

Past and current operating regimes (frequency, timing, extent and duration of water fluctuations) combined with the steep-sidedness of the reservoir shoreline precludes establishment of a viable aquatic plant community within the drawdown zone. This, in turn, has resulted in greatly reduced benthic invertebrate production compared to natural lakes. Relatively minor changes in plankton production can be expected due to alterations in nutrient concentrations, light, temperatures and grazing pressures that will result from water level changes. One direct effect of increased drawdown will likely be increased removal of plankton, utilized by fish as a food source, from the epilimnion (upper layers) of the reservoir. Data from this and other oligotrophic reservoirs such as Revelstoke and

Williston Reservoirs indicate that peak production occurs in the period July to October. Increased outflows during this period could result in plankton production being concentrated near the dam. This, in turn, could result in fish stocks being concentrated in this area, thereby exacerbating a known fish entrainment problem. However, losses to Mica fisheries resources due to increased entrainment of plankton and fish would likely be offset by positive, incremental effects on fish stocks below the dam, as has been observed downstream of Hugh Keenleyside Dam.

Lower reservoir levels associated with Regime 1 will not adversely affect access by migratory spawning fish to most tributaries. However, access to Beaver River, Wood River and Foster Creek will be affected. These three streams have natural fish migration barriers (impassable) which, at reservoir elevations above around 735 m (2410 ft), are inundated and rendered passable.

Under median Base Case (medium load) conditions, these migration barriers would be exposed in March of 4 of the 20 years studied and in April of 19 of the 20 years. Under minimum Base Case conditions, the barriers could be exposed during the periods February through April (90% exceedance) and January through May (100% exceedance), respectively.

Under Regime 1 (medium load) median conditions, these migration barriers would be exposed during the period January through May. During very dry periods, the barriers could be exposed year-round (100% exceedance) starting in 1993. However, the greatest changes (reductions) in monthly elevation would occur during the months of September through April.

Spawning periods of kokanee, Dolly Varden, whitefish and rainbow trout were noted in Section 3.2.2. As these sport fish all spawn during the periods when these migration barriers will become exposed, operation of the reservoir under Regime 1 (medium load) could have potentially adverse effects on overall fish production in Mica Reservoir by making potential spawning streams inaccessible during the spawning period, and thus cause a reduction in the amount of available tributary rearing habitat. As rainbow trout in the Columbia system typically spawn from March through June, under Regime 1 (medium load) conditions, rainbow trout spawning could be affected. Rainbow trout spawning could also be affected under Base Case conditions. However, since rainbow trout spawning coincides with spring runoff, hence reservoir filling, it is probable that rainbow trout spawning would only be delayed rather than arrested. Furthermore, it should be noted that the three streams are all of glacial origin and may be too cold for rainbow trout spawning to occur.

During excessively dry years, the migration barriers would be exposed for periods of time encompassing all or part of the spawning season for rainbow trout, Dolly Varden char, kokanee and mountain whitefish. Kokanee production would probably not be affected as this species is not known to spawn in these cold, glacial streams. Dolly Varden char and mountain whitefish production could be compromised. However, it is estimated that these three streams would only contribute between 5 and 10% of the overall reservoir production of these two species. Furthermore, losses would be confined to extremely dry years.

A succession of unusually dry years may also result in more extensive drawdowns which would greatly reduce the amount of aquatic lacustrine habitat available to fish. Fish would become concentrated in the deepest section of the reservoir(the forebay area immediately behind the dam). This could result in:

1) increased feeding activity or growth by piscivores foraging on concentrated prey species. In the short term this could prove to be beneficial to the sport fishing resource. However, after prolonged drawdown growth of fish may decrease as concentrations of prey diminish; and

2) fish becoming so concentrated in the forebay area that, as previously noted, losses could occur as a result of entrainment of fish through power generation facilities or over the spillway.

Regime 1 (ARO) Compared to Base Case (ARO)

The data indicate that the Base Case (ARO) operating regime is very similar to the Base Case (medium load) operating regime. With the Base Case (ARO), the annual average reservoir elevation during the period 1989 - 1993 would fluctuate between 748.8 and 751.3 m (2433.8 and 2441.7 ft) with an annual range of 21.5 to 24.6 m (70.0 to 79.8 ft). For the period 1994 - 2008, the annual average reservoir elevation fluctuates between 753 and 753.8 m (2447.3 and 2449.8 ft) with an annual range of 20 to 22.2 m (65.0 to 72.2 ft).

Under Regime 1 (ARO), the annual average reservoir elevation fluctuates between 733.3 and 742.1 m (2405.9 and 2434.6 ft) with an annual range of 22.8 to 28.2 m (74.8 to 92.5 ft).

There are only slight differences in reservoir elevations between Regime 1 (ARO) and Regime 1 (medium load). Therefore, the potential impacts on and/or benefits to the fishery resources of Mica Reservoir identified for Regime 1 (medium load) are directly applicable to this comparison.

Regime 1 (AOS) Compared to Base Case (AOS)

Under the Base Case (AOS), the annual average reservoir elevation for the period 1989 - 1993 would fluctuate between 748 and 750.6 m (2431.1 and 2439.4 ft) with an annual range of 21.2 m to 24.4 m (68.9 to 79.3 ft). For the period 1994 to 2008, the annual average reservoir elevation would fluctuate between 751.8 and 753.8 m (2443.3 and 2449.8 ft) with an annual range of 20.0 to 22.2 m (65.0 to 72.3 ft).

Regime 1 (AOS) will result in a large decrease in the annual elevation of Mica Reservoir over the 20 year study period compared to the Base Case (AOS). The annual average reservoir elevation would fluctuate between 730.4 and 741 m (2396.2 and 2431.1 ft). The annual range over which the water level fluctuates will increase substantially from between 20 to 22.2 m (65 to 72.3 ft) to between 22.9 to 28.7 m (75.2 to 94.3 ft).

This load scenario would result in as much as 10 m (32.5 ft) of the current wetted drawdown zone being flooded only during years of exceptionally high inflows compared to Base Case conditions. Also, outflows from the reservoir during drawdown periods will increase compared to those under Base Case conditions.

Increased outflow during drawdown periods will compound any anticipated impacts/benefits on the fishery resource associated with entrainment of plankton and planktonic stages of benthic invertebrates and possibly fish.

In the spring (April - May) of 1989, minimum reservoir elevations reached as low as 715 m (2345 ft) (O. Nagy, Water Survey of Canada, pers. comm., September 6, 1989). Reservoir levels in this range could become commonplace under Regime 1 (AOS). This could result in frequent event periods during which pelagic, lake-dwelling fish populations become so concentrated in the forebay area of the reservoir (the only section of the reservoir that maintains a lake-type habitat during periods of extensive drawdown) that entrainment of fish through the dam could be exacerbated. Furthermore, overall fish production could be compromised during periods of prolonged drawdown as elevated (concentrated) numbers of sport fish species over-exploit the likewise concentrated prey fish populations.

With Regime 1 (AOS), median reservoir elevations are below the level at which migration barriers in Beaver River, Wood River and Foster Creek could become exposed in December of 9 of the 20 years studied, from January through May in all 20 years and in June in 6 of the 20 years. With the Base Case (AOS), the barriers would be exposed occasionally in February, March and May and always in April. The only sport fish species which may be affected is rainbow trout, and, as noted, these streams likely contribute little to the overall production of the reservoir's rainbow trout population given the low water temperatures and turbid conditions prevalent in all three. During very dry years (90 and 100 % exceedances), these barriers would be exposed for nine months of the year (from October to June) from 1989 to 1992 and then all year from 1993 on, encompassing all or part of the spawning season of all four sport fish species. The species likely to be most affected are Dolly Varden char and mountain whitefish and these streams are estimated to contribute only between 5 and 10% of the overall reservoir production of these two species.

As noted, the current drawdown zone does not provide productive fish habitat. Therefore, it is unlikely that reduced overall reservoir levels will have any effect on the amount of available rearing habitat in the reservoir or its tributaries in the short term.

Long term exposure of the upper 10 m (32.5) of the currently wetted drawdown zone could lead to re-vegetation of newly exposed tributary shorelines and scouring of old stream channels to create new riverine spawning and rearing habitat.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Regime 2 (medium load) will result in a reduction in the annual average elevation of Mica Reservoir compared to the Base Case (medium load). These changes will be less than the changes associated with Regime 1 (medium load) previously described.

Essentially, all of the potential impacts on, and benefits to, fish and fish habitat of Mica Reservoir identified for the Regime 1 (medium load) - Base Case (medium load) comparison apply to the present comparison, with the exception of those impacts/benefits associated with long term exposure of the upper 5 m (16 ft) of the drawdown zone. Under Regime 2, this area of the drawdown zone will remain wetted over the long term, thereby precluding recovery of "old" tributary spawning and rearing habitat. This is also true for the Base Case.

With Regime 2, median reservoir elevations for the drawdown period February through May are usually below 731.8 m (2400.9 ft). Therefore the potential barriers to fish migration previously described for the Beaver and Wood Rivers and Foster Creek will be exposed during this period. As noted, with the Base Case, these barriers would be exposed occasionally in March and almost always in April. With Regime 2, during very dry years, these barriers would be exposed during the periods January through May (90% exceedance) and September through June (100% exceedance) until 1992, then during the periods December through May (90% exceedance) and all year round (100% exceedance) starting in 1993.

Since the period March through May falls within the spawning period for rainbow trout in the Columbia River system, rainbow trout production could be adversely affected under Regime 2 if the streams are used by rainbow trout for spawning. At the 100% exceedance levels, the migration barriers will be exposed throughout the spawning periods of all of the major sport fish species (kokanee, Dolly Varden, rainbow trout and whitefish). These impacts will apply only if these streams are important spawning grounds for each species.

Arrow Lakes Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Arrow Lakes Reservoir elevations associated with Regime 1 (medium load) compared to the Base Case (medium load) elevations are essentially identical. These changes will amount to average monthly differences in average elevations of less than 0.03 m (0.1 ft) with maximum differences of ±0.4 m (±1.3 ft). The maximum changes will occur during March.

Increased entrainment of plankton, benthic invertebrates and fish from the Arrow Lakes during periods of rapid discharge, and the expected minimal changes in water level are not expected to have any significant effect on the biological productivity, or fish resources (such as limiting accessibility to tributary fish spawning and rearing habitat) in the Arrow Lakes Reservoir.

Regime 1 (ARO) Compared to Base Case (ARO)

The reservoir operating conditions describing these load scenarios are virtually identical to those describing the Base Case (medium load) - Regime 1 (medium load) comparison. Therefore, anticipated impacts are the same as those discussed for that comparison.

Regime 1 (AOS) Compared to Base Case (AOS)

The reservoir operating conditions describing these load scenarios are virtually identical to those describing the Base Case (medium load) - Regime 1 (medium load) comparison. Therefore, anticipated impacts would be the same.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

The reservoir operating conditions describing these load scenarios are virtually identical to those describing the Base Case (medium load) - Regime 1 (medium load) comparison. Therefore, anticipated impacts are the same as those discussed for that comparison.

Downstream Area

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Under Regime 1, average monthly outflows from Arrow Lakes would increase marginally over Base Case (medium load) conditions during the period August through November and decrease January through July. With Regime 1, the highest average flow increase compared to Base Case would be 235.7 m^3/s (8322.1 ft^3/s). This would occur in September. The highest average flow reduction from Arrow Lakes (116 m^3/s (4124.5 ft^3/s)) would occur in April.

Elevated outflows from the Arrow Lakes Reservoir will likely have minor beneficial effects on the fisheries of the Columbia River downstream of Hugh Keenleyside Dam as increased outflows may result in increased numbers of juvenile fish and invertebrates from Lower Arrow Lake being entrained over the dam to the downstream area.

Increased outflows from the Arrow Lakes will result in higher water levels in the Columbia River. This will likely cause alterations in the flow regime of the river as increased water levels and velocities erode old stream banks and channels and form new ones. However, this is not expected to have a negative impact on the amount and quality of currently available spawning and rearing habitat in the river. Rearing habitat is usually found only in the near-shore margins of any stream. Given that the stream bed configuration in the Columbia River is of shallow relief, the near-shore margin habitat would exist at any flow level. Higher flow velocities may result in old spawning beds being covered up but they should also result in new ones being formed.

Available information indicates that high total dissolved gas (TDG) levels occur in the Columbia River below the Hugh Keenleyside Dam and that they are a result of large volumes of water being discharged through the sluiceway of the dam. Since the discharge from the dam is expected to increase during the period August through November, it should be expected that TDG levels will increase as well. However, since the present high total gas levels currently found in the waters downstream of the dam do not appear to have any adverse effect on fish, it is unlikely that any increase in TDG associated with the anticipated increases in maximum flows will have any significant effect.

Decreased outflows from Hugh Keenleyside Dam during the period January through July would result in small decreases in overall discharge in the Columbia River downstream of the dam which could adversely affect the fisheries of this section of the river, since important sport fish species rear and/or spawn in the Columbia River below Hugh Keenleyside Dam. For example, embayments and gravel bars in the lower river are likely spawning areas for species such as mountain whitefish which spawn October to November, the specified high water period. Such fish generally spawn in waters as shallow as 13 cm. The eggs hatch in early March. Eggs deposited during the high water period may become exposed when the late winter - early spring downward fluctuations in water depth (resulting from reduced flows) occur.

While the projected frequency of flow fluctuations is the same for both Regime 1 (medium load) and the Base Case (medium load), maximum flows will be greater than those presently experienced. Depending on river topography, stranding of fish may occur when water levels decrease.

One indirect beneficial effect of the proposed increased flows (Aug. - Nov.) will be the dilution affect of greater volumes of water flowing past the Celgar pulp treatment facilities at Castlegar. This could alleviate potential sublethal toxic effects in fish during periods of high effluent discharge. Alternatively, any potential for sublethal toxic effects associated with industrial effluent discharges or increased biological oxygen demand (BOD) could be increased when river flows are reduced as a result of reduced outflows from the Arrow Lakes during January to May. Since low water periods will occur during the period of spawning for rainbow trout (and possibly sturgeon, another of the major sport fish species), toxic effluents and/or high BOD associated with mill effluents and their concentration during periods of low discharge could directly impact the spawn of these two species, impairing the natural reproductive capabilities of those stocks. However, since minimum flows will not decrease and since new regulations regarding the effluent discharge guidelines for pulp mills have been introduced and the Celgar pulp mill effluent treatment system is being redesigned, downstream water quality should be generally improved.

4.3.3 Wildlife Resources

Mica Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

At present, variations in reservoir level, combined with other factors such as steepness of terrain, severely limit production of aquatic/wetland wildlife at Mica Reservoir. Therefore, increased annual ranges in reservoir level due to Regime 1 would have little incremental effect compared to the Base Case. Generally lower reservoir levels at times when waterfowl, shorebirds and other species are migrating along the Rocky Mountain Trench should have no adverse impact because those birds primarily rest on sandbars and mudflats and such habitats will still be available. There is little suitable feeding habitat for migrating waterfowl under Base Case conditions, and this should not change with Regime 1. An exception could involve use of shallowly flooded mudflats north of Columbia Reach Island by molting geese in July and by fall-migrant waterfowl from September through November. Although earlier and more complete drying of that area could make it less suitable, relatively small numbers of birds are involved.

A possible reduction in aquatic productivity due to loss of plankton during periods of extensive discharge of water from the reservoir could adversely affect wildlife species which depend on aquatic food chains. This includes diving ducks, loons, ospreys, bald eagles, and river otters. However, populations of those species at Mica Reservoir are small and few individuals would be affected. Reduced access into Beaver River, Wood River, or Foster Creek for spawning fish (Section 4.3.2) is not expected to have impacts on species such as bears, ospreys and bald eagles which feed on spawners, as few fish are likely to be affected.

With Regime 1, the upper part of the drawdown zone would be flooded less frequently than under Base Case conditions, according to the SAM model. In about 10 years out of 20 there might be no flooding in the upper 5 m (16 ft) zone, including runs of up to six consecutive years. This would allow early successional vegetation, probably mostly annual grasses, sedges, and weedy forbs, to become temporarily established where gradients and soil conditions are suitable. Approximately 500 to 1000 ha (1,235 to 2,470 acres) of the drawdown zone could be involved, based on estimated shoreline slopes of 30 to 50%. This could provide some benefit for terrestrial wildlife, however this region of dense conifer forest supports few species which could capitalize on such a niche. Those which could respond positively include elk (southern half of the reservoir only), black bears, and Canada geese. These species would be expected to graze on newly established grass/forb communities around the reservoir perimeter.

Lower water levels with the Regime 1 should have no adverse impact on any cross-reservoir big game movements. Seasonal timing of open water and ice cover should not change. Lower reservoir levels will mean that the crossing distance, on average, is slightly less than under Base Case conditions.

Regime 1 (ARO) Compared to Base Case (ARO)

The Base Case (ARO) is quite similar to the Base Case (medium load), and the Regime 1 (ARO) average reservoir levels and ranges are also similar to Regime 1 (medium load). Therefore, this scenario is expected to have impacts and/or benefits for wildlife at Mica Reservoir which are essentially the same as described for Regime 1 (medium load).

Regime 1 (AOS) Compared to Base Case (AOS)

Regime 1 (AOS) results in greater deviations from its Base Case than in any of the previous comparisons. It will result in a large reduction in the mean annual elevation of Mica Reservoir and a substantial increase in the annual range of water levels there. Although the use of Mica Reservoir by aquatic and wetland wildlife is apparently low at present and would be so under Base Case (AOS) conditions, the magnitude of potential impacts described for Regime 1 (medium load) would be greater. Habitat conditions for molting geese and fall-migrant waterfowl would be adversely affected; the reservoir would be less productive for wildlife species which depend on aquatic food chains; and fewer spawning fish would probably be available for bears and eagles.

The SAM data indicate that Regime 1 (AOS) would have a greater potential benefit for terrestrial wildlife than any of the other regimes. Infrequent flooding of the upper 10 m (33 ft) portion of the current drawdown zone, especially after 1991, would result in more terrestrial habitat being available around the reservoir perimeter. With this regime, reservoir levels would rise to within 5 m (16 ft) of full pool in only about 2 years out of 20, and to within 10 m (33 ft) of full pool in 11 years out of 20. There could be no flooding in the upper 10 m (33 ft) zone for runs of up to 5 years and no flooding at all in the upper 5 m (16 ft) zone after 1991. Some vegetation could, therefore, become established in the upper part of the Mica Reservoir drawdown zone. The kind and production of vegetation would vary with aspect, slope steepness, and soil conditions but some plant growth would be expected to colonize most newly exposed substrates. After 1991, up to 1000 ha (2,470 acres) could be affected and in the very long term this could undergo succession from grass-forb communities to coniferous forest. If this occurs, this area would eventually be used by most species of terrestrial wildlife which presently occur at low elevations in this area. In the zone 5 to 10 m (16 to 33 ft) below full pool, early successional stages of vegetation such as grasses, sedges, forbs and willows could become temporarily established in favourable sites, and would provide forage for moose, elk, black bears and Canada geese.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Potential impacts on wildlife species and habitats resulting from the implementation of Regime 2 are the same as discussed for Regime 1 except that their magnitude and/or likelihood of occurrence would be smaller. Potential positive effects such as a narrower reservoir for crossing animals to swim and increased terrestrial habitat in the upper drawdown zone would also be less than with the Regime 1 scenario.

Arrow Lakes Reservoir

Some important waterfowl habitats occur in the north-Arrow area and relatively large numbers of aquatic birds use that area seasonally. Relationships between reservoir levels, habitat conditions, and use by waterfowl in recent years were previously described. This information provides the only basis for assessment of potential impacts of various reservoir operation scenarios on wildlife. Evaluation of such impacts requires an assumption that habitat condition and waterfowl occurrence would be essentially the same under the various hypothetical base cases as they have been in recent years. Otherwise, valid comparisons cannot be made.

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

With Regime 1, deviations of Arrow Lake elevations from Base Case conditions are small, averaging only 0.07 m (0.3 ft). The highest average differences are up to 1 m (3 ft) in March and April. However, at that time of year reservoir levels are always well below the vegetated zone of importance for waterfowl and deviations of that magnitude should have no impact on wildlife habitat or on waterfowl occurrence.

Subtle variations in the frequency and duration of flooding of plant communities in the upper part of the Arrow Lakes drawdown zone could initiate changes in those communities which are either harmful or beneficial for wildlife. However, differences between Regime 1 and Base Case elevations at the time of year when levels are normally high (June through October) are very small, thus impacts on wildlife, if any, should be slight.

Regime 1 levels and discharge rates should not cause measurable changes in reservoir productivity of fish abundance, therefore, no impacts on wildlife species which feed on plankton, aquatic invertebrates, or fish should occur.

Regime 1 (ARO) Compared to Base Case (ARO)

Deviations in Arrow Lake elevations with Regime 1 (ARO) are similar to Regime 1 (medium load) and wildlife impacts, if any, would be slight.

Regime 1 (AOS) Compared to Base Case (AOS)

Variations in Arrow Lake elevations attributable to Regime 1 (AOS) are similar to Regime 1 (medium load), and wildlife impacts, if any, would be slight.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Deviations in Arrow Lake elevations with Regime 2 are very similar to Regime 1. Conclusions concerning potential wildlife impacts of Regime 2 are the same as for Regime 1.

Downstream Area

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Under Regime 1, average monthly outflows from Arrow Lake Reservoir will be slightly higher than Base Case flows from August through November and lower from January through July. Resulting changes in water depth and channel width in the Columbia River will be minor and are expected to have no measurable impact, positive or negative, on wildlife habitats or populations along the river.

Regime 1 (ARO) Compared to Base Case (ARO)

Flow changes would be similar to the medium load regime and no wildlife impacts should occur.

Regime 1 (AOS) Compared to Base Case (AOS)

Flow changes would be similar to the above regimes and no wildlife impacts are expected to occur.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Flow changes would be even less than with Regime 1 (medium load) and, therefore, no impacts on wildlife should occur.

4.4 Human Habitation and Resource Uses

4.4.1 Heritage Resources

Inundation of heritage sites does not necessarily adversely affect heritage resources. Rather, adverse effects result from wave action, reservoir level fluctuation, currents and seiches, wind and water erosion, stream and ice action, and redeposition of sand and silt (Mohs 1977). Site exposure during reservoir operation can also result in discovery and unauthorized removal of artifacts.

Mica Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

With Regime 1 (medium load), the two documented heritage sites at Mica Reservoir will remain inundated even with the increase in reservoir drawdown compared to the Base Case (medium load), thus will not be affected. Any undocumented heritage sites which are underwater at all times or exposed for only part of the year could be uncovered for longer periods of time with Regime 1 as the operating range is greater that the Base Case range. Disturbance by wave action, particularly at mid-range elevations, could result. The possibility of discovery and removal of artifacts without authorization is greater, although access to any sites is limited primarily to the summer months when boating and other recreation activity takes place, and the reservoir is normally at its highest elevations during this period. Average elevations during the summer months (June through September) are 5.2 m (17 ft) lower with Regime 1 than the corresponding Base Case elevations.

Regime 1 (ARO) Compared to Base Case (ARO)

The Base Case (ARO) and Regime 1 (ARO) are virtually identical to those for the medium load scenario. With Regime 1 (ARO), average elevations during the summer months are also approximately 5.2 m (17 ft) lower than Base Case elevations. Therefore, the discussion of impacts on heritage resources in comparing Regime 1 and the Base Case (medium loads) would apply in comparing Regime 1 (ARO) and the Base Case (ARO).

Regime 1 (AOS) Compared to Base Case (AOS)

Potential impacts on heritage sites with Regime 1 (AOS) compared to Base Case (AOS) are similar to those described for Regime 1 (medium load) compared to Base Case (medium load). The known heritage sites will remain inundated at all times of the year. Impacts on undocumented heritage sites could occur from exposure for longer periods of time as the Regime 1 (AOS) operating range is greater than the Base Case (AOS) range. With Regime 1 (AOS), average elevations during summer months are 9.7 m (31.8 ft) lower than corresponding Base Case elevations.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

The documented heritage sites will remain inundated at all times, thus no impacts are expected on these sites. The discussion of potential impacts on heritage sites for Regime 1 would also apply to Regime 2, although the fact that Regime 2 reservoir elevations are closest to Base Case elevations implies that any impacts would be similar. Average Regime 2 elevations during the summer months are 3.4 m (11.1 ft) lower than corresponding Base Case elevations.

Arrow Lakes Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Uncovering and disturbance of heritage sites is not expected to be a greater problem with Regime 1 than it may be for the Base Case. Average monthly elevations are slightly higher with Regime 1 than with the Base Case, although differences are not greater than 1 m, implying that sites may be slightly less exposed with Regime 1. During July, August and September, when most recreation use occurs, the reservoir is at or very near full pool. Therefore, no incremental impacts would be expected with Regime 1.

Regime 1 (ARO) Compared to Base Case (ARO)

Average elevations at Arrow Lakes Reservoir with Regime 1 (ARO) are virtually identical to those for the Base Case (ARO). These values are also virtually identical to those for the Base Case and Regime 1 (medium loads), the greatest difference being that the lowest average elevations in February are lower by less than 0.6 m (2 ft) and are higher by less than 0.6 m (2 ft) in March. These differences are negligible, therefore, the discussion of impacts on heritage sites comparing the Base Case and Regime 1 (medium loads) would also apply to the Base Case and Regime 1 (ARO).

Regime 1 (AOS) Compared to Base Case (AOS)

Changes in Arrow Lakes Reservoir elevations with Regime 1 (AOS) compared to Base

Case (AOS) are negligible when considering potential impacts on heritage sites. During July, August and September, it is at or very near full pond with both Regime 1 (AOS) and the Base Case (AOS). In other months, reservoir elevations differ by less than 0.3 m (1 ft). Thus, no incremental impacts on heritage sites are expected with Regime 1 (AOS).

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Changes in average Arrow Lakes Reservoir elevations with Regime 2 compared to the Base Case are so slight as to be negligible (generally less than 0.3 m (1 ft)). During July, August and September, when most recreation use occurs, the reservoir is at or near full pool with both the Base Case and Regime 2. There are only slight differences in the annual operating range of less than 1 m (3 ft) and the timing of filling and drawdown is virtually identical. Therefore, no incremental impacts would be expected with Regime 2 compared to the Base Case.

Downstream Area

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Daily fluctuations in present outflows can range from a minimum of 140 m^3/s (5000 ft^3/s) to a maximum of 2550 m^3/s (98,000 ft^3/s). Corresponding water level elevations for these flows just below the Hugh Keenleyside Dam are approximately 417 m (1368 ft) and 422 m (1386 ft), although the inflow of the Kootenay River downstream of Castlegar has a significant effect on river water levels (L. Arishenkoff, Lockkeeper, Hugh Keenleyside Dam, pers. comm., May 8, 1989). Known heritage sites below El. 422 m (1386 ft) have likely already been disturbed and no new impacts are expected with Regime 1 or the Base Case. The two heritage sites at El. 424 m (1391 ft) which have been judged in the past studies to warrant conservation or mitigation procedures, and any other undocumented sites, will not be affected by average flows. While maximum flows will be higher than those presently released with both Regime 1 and the Base Case (maximum flows are projected to be as high as 3115 m^3/s (110,000 ft^3/s), the river stage associated with such flows is approximately 423 m (1388 ft) (immediately below Hugh Keenleyside Dam), river stage downstream drops considerably, therefore impacts on these sites are unlikely. One of these sites is downstream of the confluence of the Columbia and Kootenay Rivers. No incremental impacts are anticipated as a result of implementing Regime 1 (medium load) rather than the Base Case.

Regime 1 (ARO) Compared to Base Case (ARO)

Average outflows from the Hugh Keenleyside Dam under the Base Case and Regime 1 (ARO) are virtually identical to those for the Base Case and Regime 1 (medium load). However, maximum flows with both the Base Case (ARO) and Regime 1 (ARO) are as high as 3342 m^3/s (118,000 ft^3/s). The elevation associated with this flow is approximately 424 m (1391 ft), under the dam, however, river stage downstream of the dam drops considerably, therefore these sites are unlikely to be affected.

Regime 1 (AOS) Compared to Base Case (AOS)

Average outflows under Regime 1 (AOS) differ only slightly from outflows under Regime 1 (medium load) and the two Base Cases (medium load and AOS) are also only slightly different. Therefore, the discussion of potential impacts comparing the Base Case (medium load) and Regime 1 (medium load) would also apply to this comparison. No incremental impacts due to the implementation of Regime 1 (AOS) rather than the Base Case (AOS) are anticipated.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Potential impacts due to Regime 2 (medium load) outflows compared to Base Case (medium load) conditions are similar to those for Regime 1 (medium load). No incremental impacts due to the implementation of Regime 2 rather than the Base Case are anticipated.

As noted, two of the known heritage sites along the Columbia River are at El. 424 m (1391 ft). These would not be affected by average flows under either regime. Impacts due to maximum flows under either regime are also unlikely. The two sites below El. 422 m (1385 ft) have already likely been disturbed, thus no new impacts would be expected.

4.4.2 Settlements

Mica Reservoir

There are no settlements located adjacent to Mica Reservoir and none depend on the reservoir for water supply. Therefore, there are no adverse impacts on settlements as a result of any of the four alternative operating regimes or their associated base cases.

Arrow Lakes Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Settlements on the Arrow Lakes Reservoir are not expected to incur noticeable impacts from the slight alteration in annual average reservoir elevations under Regime 1 compared to the Base Case, over and above those which presently occur as a result of reservoir drawdown, such as dust, access, and navigation difficulties. The Celgar water supply intake pipe which supplies Castlegar's water would not be affected by the small changes in elevation contemplated with the Regime 1 (medium load) regime, over those with the Base Case (medium load). Lake ferries do not presently have any navigation difficulties and are not expected to do so under Base Case or Regime 1 conditions.

Regime 1 (ARO) Compared to Base Case (ARO)

Arrow Lakes Reservoir elevations for the Base Case (ARO) and Regime 1 (ARO) are virtually identical, therefore, potential impacts on settlements would be the same for either of these regimes. No impacts over and above those presently occurring would be expected with the implementation of either regime.

Regime 1 (AOS) Compared to Base Case (AOS)

Differences in Arrow Lake elevations for the Base Case (AOS) and Regime 1 (AOS) are negligible. No impacts on settlements would result from implementation of either of these regimes, over and above those presently occurring.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

As the Regime 2 (medium load) regime is very similar to the Base Case (medium load), no impacts are expected on settlements, other than those presently occurring as a result of reservoir drawdown.

Downstream Area

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

The majority of communities along the Columbia River downstream of the Hugh Keenleyside Dam are not expected to be affected by the small changes in average monthly river flows with Regime 1 (medium load) compared to the Base Case (medium load), as their drinking water is not supplied by the river, and they have already adjusted to fluctuating flows. Prior to the creation of reservoirs upstream, maximum flows during flood years were three or four times greater than present maximum flows. However, the City of Trail apparently experiences some minor flooding problems during current maximum flow periods (L. Godberson, Lockkeeper, Hugh Keenleyside Dam, pers. comm., November 20, 1989). This situation can be expected to continue or to be exacerbated with the slight rise in river stage (> 0.6 m (2 ft)) projected with the Regime 1 (medium load) and Base Case (medium load) maximum flows. (The river stage rises approximately 0.3 m (1 ft) for every additional 142 m^3/s (5000 ft^3/s)).

The intake in the river which supplies the Cominco smelter at Trail with process and in-plant drinking water, and also supplies the Village of Warfield and the Trail subdivision of Tadanac with drinking water, will not be affected under average conditions. Although the Regime 1 average flows in late April (368.5 m^3/s (13,014.1 ft^3/s)) are slightly lower than the 425 m^3/s (15,000 ft^3/s) needed for the intake to function adequately, average outflows in late April from the Kootenay River, which joins the Columbia River upstream of the intake, are 699 m^3/s (24,679 ft^3/s)[1], thus no operating problems are anticipated during this month. However, prolonged periods of minimum flows could create problems for this intake and for loading the Ministry of Forests' water bomber.

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[1] BCHPA Water Records - derived from flows at Brilliant Dam, April 15 - 30, 1968 to 1989.

Regime 1 (ARO) Compared to Base Case (ARO)

Average outflows for the Base Case (ARO) and Regime 1 (ARO) are very similar to outflows for Regime 1 and Base Case (medium loads). Potential impacts on settlements would thus be the same for this comparison. Prolonged periods of minimum flows may affect the Cominco intake and cause problems in loading the Ministry of Forests' water bomber. Maximum flows for Regime 1 (ARO) and the Base Case (ARO) are higher than the other regimes studied (up to 3442 m^3/s (118,000 ft^3/s)) and the associated rise in river stage (1.2 m (4 ft)) may exacerbate minor flooding problems at Trail.

Regime 1 (AOS) Compared to Base Case (AOS)

Outflows with Regime 1 (AOS) compared to the Base Case (AOS) are again very similar to those under the medium load scenario. Minimum flows may affect the Cominco intake and cause problems in loading the Ministry of Forests' water bomber. Maximum flows are similar to the medium load scenario and a rise in river stage of >0.6 m (2 ft) can also be expected with the AOS regime, which may exacerbate minor flooding problems in Trail.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

As with the other scenarios, the majority of communities along the river will not be significantly affected by the slight changes in average monthly outflows with Regime 2 (medium load) compared to the Base Case (medium load). However, prolonged periods of minimum low flows may create problems for the Cominco intake and for the Ministry of Forests' water bomber loading facility. Regime 2 (medium load) and the Base Case (medium load) maximum flows are similar to those for Regime 1 (medium load) and are higher than present maximum flows. The resulting rise in river stage could exacerbate minor flooding problems in Trail.

4.4.3 Forestry

Mica Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Average reservoir elevations are approximately 5.5 m (18 ft) lower with Regime 1 (medium load) compared to the Base Case (medium load) during June through October, when water-based forestry activities occur on Mica Reservoir. Therefore, the problems forest companies experience with fluctuating reservoir levels, and particularly with low levels, will be exacerbated with Regime 1. All companies using the reservoir at present have to rebuild most, if not all, of the barge points, and dump and dewatering sites each year and this would continue, and possibly be necessary more frequently. With the Base Case, the lowest median elevations for June through October are all above the 741 m (2430 ft) level needed to operate Evans Forest Products' dewatering site at Bush Harbour and are also above the 744 m (2440 ft) level needed to operate Slocan Forest Products' dewatering site in the northern portion of the reservoir. With Regime 1, median elevations in June are often below 741 m, which would cause problems at both dewatering sites. Levels in July through October are sufficient for operation of these sites. To operate in June, modifications such as lengthening ramps and skids will be required, which will add to operating and maintenance costs, or start-up may be delayed. Westar's ramps and skids will also need to be lengthened at barge points and log dumps. In very dry years, minimum elevations (90% and 100% exceedance) are below 741 m throughout all the months of operation with Regime 1. With the Base Case, they are below 741 m during all operating months except August with 100% exceedance conditions, but well above under 90% exceedance conditions.

Lower reservoir elevations with Regime 1 will cause increased navigation problems for log towing in shallow areas near log dewatering sites such as Evans Forest Products' site at Bush Harbour. Navigation difficulties from protruding stumps in local shallow sites such as Bush Harbour commence at 739 m (2425 ft). During several years of the study period (6 out of 20), June elevations are at or below this level with Regime 1, although they are above 739 m in all other operating months. Minimum elevations (100% and 90% exceedance) during July to October are too low for navigation in the majority of years, with

Regime 1. By comparison, minimum elevations (100% exceedance) with the Base Case are a problem only in June and October of some years (7 and 3 out of 20, respectively).

Regime 1 (ARO) Compared to Base Case (ARO)

Elevations of Mica Reservoir under Regime 1 (ARO) and the Base Case (ARO) are virtually identical to those for Regime 1 (medium load) and the Base Case (medium load). Differences in elevation are generally less than 0.3 m (1 ft) between the two energy load scenarios. Therefore, the discussion of potential impacts on forestry under the medium load scenario would also apply to the ARO energy load scenario.

Regime 1 (AOS) Compared to Base Case (AOS)

As elevations are substantially lower with Regime 1 (AOS) than with any other proposed operating regime, this energy load regime will generally have the greatest impacts on forest industry activities in the area. With Regime 1 (AOS), the average elevations are approximately 9 m (30 ft) lower over the June through October operating period. Elevations for June through October with the Base Case (AOS) are all above the 739 m (2425 ft) level, so that no problems would occur with navigation and most barge points. Slocan Forest Products' log removal and dumping site would be slightly affected as, in June of 2 of the 20 years studied, median Base Case (AOS) elevations are below the 744 m (2440 ft) level needed to operate the site at the northern end of the reservoir. With Regime 1 (AOS), median elevations are at or below 739 m (2425 ft) in June of 16 of the 20 years studied, therefore, problems would occur with forestry activities then. Elevations in July and August are above this level but are below in September and October, in 1 and 4 of the 20 years studied, respectively. As well, with Regime 1 (AOS), median elevations are below 744 m (2440 ft) in June of all 20 years, in July of 12 years, in August of 11 years, in September of 14 years, and in October of 17 of the 20 years studied, so that Slocan's dewatering site could not operate then. Minimum elevations (100% and 90% exceedance) during all months of logging operations are too low for navigation (739 m (2425 ft)) in 19 of the 20 years studied, with Regime 1 (AOS). With the Base Case, minimum elevations (100% exceedance) are a problem for navigation in June in 11 years, in October in 4 years and in all operating months in 1 of the 20 years studied. Elevations under 90% exceedance conditions are above 739 m (2425 ft) during all operating months.

With lower elevations, some barge points, log dumps and dewatering sites will require modification by lengthening ramps and skids, which would add to operating and maintenance costs. Some companies may have to delay start-up until July and may have difficulties even then.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Impacts on navigation and log dewatering would be less severe with Regime 2 than with the other regimes. With Regime 2, the average elevations are approximately 3.8 m (12.6 ft) lower over the June through October logging period compared to Base Case elevations. No problems would be experienced with navigation, barging, and log dumping and removal in all operating months with median elevations under either Regime 2 or the Base Case. However, minimum elevations (100% exceedance) are lower than 739 m (2425 ft) needed to navigate in shallow areas such as Bush Harbour during June through October in the majority of years with Regime 2. The 90% exceedance curve is always above this level during June through October. As noted above, minimum elevations (100% exceedance) are below this in June (7 out of 20 years) and October (3 out of 20) with the Base Case (medium load).

Arrow Lakes Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

The very small differences in average monthly reservoir elevations between Regime 1 (medium load) and the Base Case (medium load), coupled with the fact that the range of elevations will not change compared to the Base Case, will result in slight, if any, impacts on water-based forestry activities, over and above those presently experienced. Westar, the only company using the reservoir for water-based storage and transport, currently experiences operating problems due to reservoir fluctuations and cannot use some log dumps when reservoir levels are at their lowest. At present, problems begin to be experienced with the reservoir at about El. 427 m (1401 ft). According to the Base Case projections, median reservoir elevations during February through April are very close to or lower than 427 m. With Regime 1, similar elevations occur during the same months.

Minimum elevations (90 and 100% exceedance) are below 427 m in December or January through May or June of all years with both regimes.

The Celgar water intake is approximately 19 m (64 ft) below the lowest median reservoir elevation in March, the lowest water month, with Regime 1 and slightly lower with the Base Case and is well below absolute minimum elevations (approximately 15 m (49 ft)), therefore no impacts are expected.

Regime 1 (ARO) Compared to the Base Case (ARO)

Elevations projected for Regime 1 and the Base Case (ARO) are virtually identical to those for Regime 1 and the Base Case (medium loads). Therefore, the discussion of potential impacts for the medium load scenario also apply to the ARO load scenario.

Regime 1 (AOS) Compared to Base Case (AOS)

Differences in elevations of the Arrow Lakes Reservoir with Regime 1 (AOS) compared to Base Case (AOS) are very small and similar to those between Regime 1 (medium load) and the Base Case (medium load). Therefore, the discussion of potential impacts with Regime 1 (medium loads) compared to Base Case (medium loads) would also apply to Regime 1 (AOS) and the Base Case (AOS).

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

As changes in monthly and annual average elevations over the 20 year study period with Regime 2 are generally under 0.3 m (1 ft) compared to the Base Case, negligible impacts on water-based log transport and storage are anticipated beyond those presently experienced.

Downstream Area

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Monthly increases in outflows during August to December and decreases from January to

July with Regime 1 (medium load) compared to the Base Case (medium load) are small. Present problems encountered by Westar in navigation, log storage and mill feeding operations may be exacerbated. Westar presently encounters problems at flows above 1840 m³/s (65,000 ft³/s) and below 255 m³/s (9000 ft ³/s). With the Base Case and Regime 1, median flows are above 1840 m³/s (65,000 ft³/s) only in January. Flows in all months are above 255 m³/s (9000 ft ³/s). However, minimum monthly flows below 255 m³/s (9000 ft ³/s) are projected during March through June with both the Base Case and Regime 1. Maximum monthly flows are projected above 1840 m³/s (65,000 ft³/s) during December through February and May through August, occasionally reaching as high as 3115 m³/s (110,000 ft³/s). While the frequency of occurrence of monthly minimum and maximum flows appears to be the same for both Regime 1 and the Base Case, incremental impacts may occur due to more frequent daily flow changes from the implementation of alternate regimes.

Regime 1 (ARO) Compared to Base Case (ARO)

Outflows downstream of Hugh Keenleyside Dam with the ARO energy load scenario are very similar to those for the medium load scenario. Therefore, the discussion of potential impacts on the forest industry in comparing Regime 1 (medium load) and Base Case (medium load) would also apply to Regime 1 (ARO) and Base Case (ARO). The only difference is that maximum flows with Regime 1 (ARO) and the Base Case (ARO) will reach as high as 3342 m³/s (118,000 ft³/s).

Regime 1 (AOS) Compared to Base Case (AOS)

Outflows downstream of Hugh Keenleyside Dam with the AOS energy load scenario are very similar to those for the medium load scenario. Therefore, the discussion of potential impacts on the forest industry in comparing Regime 1 (medium load) and Base Case (medium load) would also apply to Regime 1 (AOS) and Base Case (AOS).

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Under both Regime 2 (medium load) and the Base Case (medium load), median flows in January are higher than 1840 m³/s (65,000 ft³/s), and Westar would have operation problems. In all other months, median flows would permit efficient operation of the sawmill. However, minimum flows below 255 m^3/s (9000 ft^3/s) are projected during March through June with both the Base Case and Regime 2. Maximum flows above 1840 m^3/s (65,000 ft^3/s) are projected during December through February and May through August, reaching as high as 3115 m^3/s (110,000 ft^3/s). As the frequency of occurrence of these monthly flows appears to be the same for both Regime 2 and the Base Case, incremental impacts may occur due to more frequent daily flow changes from the implementation of alternate regimes.

4.4.4 Agriculture

Mica Reservoir

There are no agricultural activities bordering the Mica Reservoir, therefore, no impacts will result on this resource use from changes in reservoir operation under any of the regimes considered.

Arrow Lakes Reservoir

The minor changes in water levels with any of the regimes considered will not restrict any of the limited agricultural activities presently occurring around the reservoir, or cause incremental impacts. No irrigation or stock watering is dependent on the reservoir.

Downstream Area

No impacts on the limited amount of agricultural activity along the shores of the Columbia River downstream of Hugh Keenleyside Dam are expected due to changes in outflows of any of the regimes studied.

4.4.5 Recreation

Mica Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Recreational use occurs mainly from June through September when the Mica Reservoir is filling. Although use can commence in May, recreation use is impaired in years when the reservoir does not fill to high levels. Average elevations during these months are 5.2 m (17 ft) lower with Regime 1 than with the Base Case. This substantial decrease in reservoir levels during June through September under Regime 1 compared to Base Case will cause access problems and an unattractive exposed drawdown area which will detract from the recreational appeal of the area.

Wood debris has posed hazards to boaters from the time of reservoir creation. As previously noted, BCHPA has recently initiated a floating debris removal program and is proposing to expand the program if reservoir levels are high enough to permit removal of beached material. If the program is expanded, it should greatly alleviate the dangers to navigation from floating debris.

Hazards to boaters from protruding stumps apparently occur in the shallow northern and southern ends of the reservoir. At Bush Harbour, the problem occurs at elevations below 739 m (2425 ft). With Regime 1, median elevations are lower than or near this level in June in 6 of the 20 years studied. Base Case elevations during all recreation months are above this level over the study period. With Regime 1, minimum elevations during June through September are too low for safe navigation in 19 of the 20 years studied. By comparison, minimum Base Case elevations are a problem only in June in 7 of the 20 years.

With median Base Case elevations, all boat launch ramps will be usable from June through September. Under median conditions, with Regime 1 (medium load), ramps extending to El. 742 m (2435 ft) will not be usable in June in 15 of the 20 years, and those extending to El. 739 m (2425 ft) will not be usable in 6 of the 20 years. No problem will occur with ramps extending to El. 735 m (2410 ft) in June or with any of the ramps in July, August or September. A new ramp planned for the Horse Creek Forest Service Recreation Site, which will extend to El. 728 m (2388 ft), will not be affected by changes in median elevation of the reservoir under any of the alternate regimes. Minimum elevations are generally always too low for use of the boat launch ramps.

Some ramps may be able to be lengthened to accommodate lower reservoir elevations. However, this may not be practical at local sites where the slope becomes greater than 10% or 12%, which is a typical grade for a ramp, or if the bottom flattens considerably, as it does at Valemount, which would necessitate an extremely long ramp. The cost of altering ramps to be usable to low water will be high since a ramp with a 12% slope covering a maximum 28.4 m (93 ft) range would have to have a length of approximately 244 m (800 ft). Such a long distance will be difficult for cars trailing boats to back down, and a new design incorporating a wider ramp or a turn-out near the foot of the ramp may be required. Site-specific data would be required to estimate the feasibility of lengthening ramps.

With minimum elevations in June through September (which could occur infrequently in years of low inflow), private resorts in the southern half of the reservoir (at Esplanade Bay and Beavermouth Creek) and recreation sites at the northern end will be severely impacted by lack of access for recreational boating and fishing.

Proposed changes in reservoir operation will need to be taken into account during development of new recreation sites, such as the new Forest Service Recreation Sites on Glacier Creek and Wisted Creek, and the potential Provincial Park in the vicinity of Potlatch Creek where boat launches usable to low water are planned.

Regime 1 (medium load) will thus create impacts on access, navigation, and general attractiveness of the reservoir. Sport fish populations may be affected with Regime 1 (section 3.2.2) which may compound access and navigation impacts on recreational fishing. However, impacts on sport fish are expected to be small. Recreational hunting should not be affected.

Regime 1 (ARO) Compared to Base Case (ARO)

The discussion of potential impacts on recreation for the medium energy load scenario also apply to the ARO load scenario as the elevations projected are virtually identical.

Regime 1 (AOS) Compared to Base Case (AOS)

Average elevations with Regime 1 (AOS) are significantly lower than with any other proposed operating regime. During the recreation months (June through September), the average reservoir elevations are 8.8 m (29 ft) lower than with the Base Case (AOS). Such a large difference in elevation will detract from the recreational quality of the area as access and navigation problems will increase and a very large unattractive drawdown area will be exposed.

Median elevations during June in 16 of the 20 years studied are lower than 739 m (2425 ft) with Regime 1 (AOS), therefore, boating will be hazardous during June in shallow parts of the reservoir. Elevations are well above the 739 m (2425 ft) level in July and August but the lowest elevation in September is below this level. In comparison, Base Case (AOS) median elevations are well above this level in June through September.

With the Base Case (AOS) median elevations, all boat launch ramps will be usable in the main recreation months of June through September. Under Regime 1 (AOS) median conditions, ramps to El. 742 m (2435 ft) will not be usable in June in 18 of the 20 years studied, those to El. 739 m (2425 ft) will not be usable in 16 of the 20 years, and those to El. 735 m (2410 ft) will not be usable in 6 of the 20 years. In July, August and September, problems will be experienced with ramps extending to El. 742 in 4, 3 and 8 of the 20 years, respectively. Ramps extending to lower elevations will be usable during these months. While it may be feasible to lengthen some ramps, site-specific evaluations would be required. A new ramp at Horse Creek will not be affected. Minimum elevations are generally always too low for use of boat launch ramps. Private resorts would also be severely affected under minimum conditions. Future development of recreation sites with boat launches usable to low water will need to take changes in reservoir operation into account.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Average reservoir elevations during May through September with Regime 2 are 4 m (13 ft) lower than with the Base Case. A greater unattractive exposed drawdown zone and increased access problems will detract from the recreational quality of the area.

Elevations during June through September are above 739 m (2425 ft) with Regime 2, thus navigation hazards due to snags, even in Bush Harbour, are not a concern. Minimum elevations during June through September are too low for safe navigation in 19 of the 20 years studied. By comparison, minimum elevations with the Base Case are a problem in June in 7 of the 20 years.

With Regime 2 (medium load) median elevations, a problem is encountered only for the boat launch ramps extending to El. 742 m (2435 ft) during June in 12 of the 20 years studied. No problems would occur for any of the ramps in any other recreation month. The new ramp planned at Horse Creek would not be affected. Most boat launch ramps will not be usable with Regime 2 under minimum conditions in any recreation months. Future development of recreation sites and boat launch ramps will need to take lower reservoir elevations into consideration.

Arrow Lakes Reservoir

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

The very slight differences in Arrow Lakes elevations between the Base Case (medium load) and Regime 1 (medium load) are not expected to affect recreation, over and above the problems presently experienced. The main recreation period is May to September, with most recreational activity occurring during June, July and August. The highest difference in average elevations between the Base Case and Regime 1 during this period is 0.09 m (0.3 ft). A reservoir elevation of 433 m (1420 ft) is considered the optimum lower limit of recreation site usability to optimize demand satisfaction without excessively separating the shoreline from base facilities above the high water line. With Regime 1 and the Base Case, median reservoir levels are below 433 m in May of all years but this is the only month which this situation occurs. The same is true for the Base Case. However, minimum reservoir elevations are normally below 433 m for the Base Case in June through September but only rarely for Regime 1, thus recreational access to the reservoir should be generally improved.

No significant impacts are predicted on sport fish and wildlife, therefore recreational fishing and hunting will not be affected by the change in operating regime.

Regime 1 (ARO) Compared to the Base Case (ARO)

Elevations projected for Regime 1 (ARO) and the Base Case (ARO) are virtually identical to those for Regime 1 and the Base Case (medium loads) during May through September when the reservoir is used for recreation. Therefore, the discussion of potential impacts on recreation for that energy loading scenario will also apply to the ARO load scenario. Minimum elevations are occasionally below 433 m (1420 ft) during recreation months with both the Base Case (ARO) and Regime 1 (ARO) regimes.

Regime 1 (AOS) Compared to Base Case (AOS)

During the recreation months, the highest difference in average elevations between the Base Case (AOS) and Regime 1 (AOS) is 0.09 m (0.3 ft), which is negligible. As with all other regimes, median elevations during May with both Regime 1 (AOS) and the Base Case (AOS) are below the optimal level for recreation of 433 m (1420 ft). Minimum elevations are sometimes below 433 m with both Regime 1 (AOS) and the Base Case (AOS) during the other recreation months (June through September).

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Differences in reservoir elevations are negligible with Regime 2 compared to the Base Case. These differences are not expected to affect recreation activity. Minimum elevations are normally below 433 m in June through September with the Base Case, but only rarely with Regime 2, thus access should be generally improved.

Downstream Area

Regime 1 (Medium Load) Compared to Base Case (Medium Load)

With Regime 1 (medium load), the slight changes in average outflows projected with Regime 1 compared to the Base Case should not significantly affect recreation facilities, which have been constructed to accommodate changes in flows. However, recreational boaters could experience navigation and access difficulties during prolonged periods of maximum or minimum flows with both Regime 1 and the Base Case and more frequent daily flow fluctuations. Maximum flows projected are higher than those presently released for both Regime 1 and the Base Case.

Regime 1 (ARO) Compared to Base Case (ARO)

Outflows for the ARO energy load scenario are very similar to those for the medium energy load scenario. Potential impacts on recreation would be the same for this comparison. Of all the regimes studied, maximum flows are highest for Regime 1 (ARO) and the Base Case (ARO) (up to 3342 m^3/s (118,000 ft^3/s)).

Regime 1 (AOS) Compared to Base Case (AOS)

Outflows with the AOS energy load scenario are again very similar to those under the medium load scenario and potential impacts would be the same for this comparison.

Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Slight decreases in average outflows in May through July and slight increases in August through December will not significantly affect recreation facilities and use of the river. Impacts on access and navigation will occur more as a result of prolonged periods of maximum or minimum flows with both Regime 2 (medium load) and the Base Case (medium load). Maximum flows projected are higher than those presently experienced for both cases.

5.0 CONCLUSION

The proposed increase in the use of non-treaty storage behind Mica Dam for energy production will have the greatest potential effects on fish, fish habitat, forestry and recreation in the Mica Reservoir. Regime 1 (medium load), Regime 2 (medium load) and Regime 1 (ARO) would have generally similar effects and may all be implemented at certain times in extending and expanding the Non-Treaty Storage Agreement. Potential impacts resulting from implementation of Regime 1 (AOS) would have the greatest magnitude as the projected physical changes resulting from this regime are the greatest.

Impacts on fish and fish habitat are expected to be small with all regimes and offset somewhat by benefits such as recovery of fish habitat in the lower sections of tributary streams. Both negative effects and potential benefits are expected to be greatest with Regime 1 (AOS).

As average elevations are significantly lower with Regime 1 (AOS) than with any other proposed operating regime, more severe impacts on forest industry activity will result. In June in the majority of years of the 20 year period, average water levels would be too low for navigation, log dumping, barging and log removal in the shallow northern and southern areas of the reservoir. Average elevations would be sufficient for most such activities in the other operating months (July through October). However, in several years over the 20 year study period, certain log dewatering sites could not be operated under average conditions in all months of forestry operations. These problems would be experienced to a more limited extent with the implementation of the other regimes.

Implementation of the alternate regimes will create impacts on recreational access to the reservoir, navigation and general attractiveness. Regime 1 (AOS) will have the greatest impacts. Navigation in June will be affected in several years under average Regime 1 (medium load and ARO) and in the majority of years with Regime 1 (AOS). The problem would not occur with Regime 2 (medium load). Boat launch ramps will not generally be usable in May with any of the regimes, and several will not be usable during other recreation months, particularly June. Minimum elevations are generally always too low for use of the boat launch ramps. Use of the reservoir by patrons of private resorts would be impacted under minimum elevation conditions with all regimes due to the very restricted access and navigation difficulties near these sites. Sport fish populations may be affected which may compound access and navigational impacts on recreational fishing.

The potential effects of all four alternate regimes on the environmental resources of the Arrow Lakes Reservoir are minimal. The projected Arrow Lakes Reservoir elevations are very similar to the associated base case elevations, the average monthly difference being very small. Fish and fish habitat would not be affected by such small differences. Water-based forestry activities and recreation would also not be affected.

Elevated outflows from Hugh Keenleyside Dam during August to December and decreased outflows from January through July would result from the implementation of all the regimes. Such changes could have minor effects, both negative and positive, on fish and fish habitat in the Columbia River below the dam. Present problems with water-based forestry activities may be exacerbated. Potential effects would be similar with all regimes. Recreation is not expected to be significantly affected by the small changes in outflows projected with the different regimes.

As virtually all potential impacts would be realized on the Mica Reservoir, it is recommended that BCHPA implement a Mica Reservoir Compensation Program to offset the potential impacts. Such a program would be similar to the present Williston Compensation Program, which utilizes the interest from a trust fund for compensation activities.

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APPENDIX 1

Streams Sampled and Species of Fish Captured in 1962 and 1963 in the Area of the Proposed Mica Reservoir

APPENDIX 1

Streams Sampled and Species of Fish Captured in 1962 and 1963 in the Area of the Proposed Mica Reservoir[1]

NAME OF STREAM	FLOW (CFS)	WATER TEMP. °F	SPECIES OF FISH SAMPLED	REMARKS
Gold River	200-300	46°	Prosopium williamsoni	fish found only below flood line
Bush River	---	48°	Prosopium williamsoni	fish found throughout the stream
			Salmo gairdnerii	found in an adjacent lake
			Cottus cognatus	
Succour Creek	60	45°	Prosopium williamsoni	
			Rhinichthys cataractae	
			Cottus rhotheus	
			Salmo gairdnerii	captured in large numbers
Smith Creek	80	43°	Prosopium williamsoni	no fish above 2350 feet
Swan Creek	60	39°	Prosopium williamsoni	
			Salvelinus malma	
			Salmo gairdnerii	

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1 Source: Peterson and Withler (1965a)

NAME OF STREAM	FLOW (CFS)	WATER TEMP. °F	SPECIES OF FISH SAMPLED	REMARKS
Double Eddy Creek	180	39.5°	Prosopium williamsoni (fry and adults)	
			Salmo gairdnerii	
Game Creek	40	47°	Savelinus malma (fry, juveniles and adults)	found in large numbers
			Prosopium williamsoni	
			Salmo gairdnerii	
			Salmo clarkii lewisi	
Caribou Creek	80	44°	Savelinus malma (fry and adults)	fish found throughout stream
			Salmo gairdnerii	
Boulder Creek	35	46°		
Sullivan River		47°	Prosopium williamsoni (fry and juveniles)	
			Richardsonius balteatus	captured near mouth of stream
			Catostomus catostomus	
			Rhinichthys cataractae	
			Cottus cognatus	

NAME OF STREAM	FLOW (CFS)	WATER TEMP. °F	SPECIES OF FISH SAMPLED	REMARKS
Windy Creek	49	42°	Prosopium williamsoni	captured in large numbers
			Cottus cognatus	
			Lota lota	
Kinbasket River	400	40°	Prosopium williamsoni	captured in large numbers
			Prosopium coulteri	
			Cottus cognatus	
Trident Creek	60	44.5°	Prosopium williamsoni	
			Prosopium coulteri	
			Salvelinus malma	
			Cottus cognatus	
			Lota lota	
Unnamed Creek	40	40°	---	
Tsar Creek	60	44°	Prosopium williamsoni (fry and adults)	
			Salvelinus malma (fry and adults)	adults observed in lower 500'
			Salmo gairdnerii (fry)	
			Cottus cognatus	

NAME OF STREAM	FLOW (CFS)	WATER TEMP. °F	SPECIES OF FISH SAMPLED	REMARKS
Cummins River	200	51°	Prosopium williamsoni (adults)	
Wood River	---	47°	Prosopium williamsoni (adults and fry)	no fish obtained above 2340' elevation
			Rhinichthys cataractae	
			Mylocheilus caurinum	
			Catostomus catostomus	
			Cottus cognatus	
Canoe River	---	47°	Prosopium williamsoni (fry, juveniles and adults)	captured throughout entire length of stream
			Cottus cognatus	
			Salmo gairdnerii (fry and adults)	
			Salvelinus malma (adults)	
Molson Creek	50	---	Prosopium williamsoni	captured near mouth
			Cottus cognatus	
Hugh Allan Creek	300	42°	Prosopium williamsoni (fry, juveniles and adults)	captured in large numbers

NAME OF STREAM	FLOW (CFS)	WATER TEMP. °F	SPECIES OF FISH SAMPLED	REMARKS
Ptarmigan Creek	200	42°	Prosopium williamsoni	
			Salmo gairdnerii	
Bulldog Creek	50	42°	---	
Yellowjacket Creek	70	42°	---	
Camp Creek	500	---	Salmo gairdnerii	large trout (10-20 pounds observed)
Potlatch Creek	40	46°°		
Nagle Creek	100	47°	Salmo gairdnerii (juveniles)	
			Salmo gairdnerii	
			Salvelinus malma	
			Prosopium williamsoni	

APPENDIX 2

Birds and Mammals (or their sign) Observed in the Mica Reservoir Drawdown Zone or Water Surface, October 18 - 19, 1988

APPENDIX 2

Birds and Mammals or Their Sign Observed in the Mica Reservoir Drawdown Zone or Water Surface, October 18-19, 1988[1]

Species	Valemount Flats	Columbia Reach Isl.	Bush Arm and Delta	Other Areas	Total
Birds					
Common loon			2	2	4
Western grebe		1			1
Tundra swan	1				1
Canada goose	S (M)	S (A)	S (R)	12	12
Mallard	2	209			211
Green-winged teal	18	3			21
Pintail		4			4
Northern shoveler	2				2
Bufflehead		6	6		12
Barrow's goldeneye		5			5
Scaup sp.			1		1
Ruddy duck		1			1
Surf scoter			3		3
Hooded merganser	1				1
Common merganser			3		3
Dowitcher		9			9
Killdeer		1			1
Snipe	1	2			3
Great-blue heron		1	2		3
Ring-billed gull			1		1
Rusty blackbird	1				1
Marsh hawk		1			1
Bald eagle		1			1
Raven	2		2		4
Northern shrike	1				1
Water pipit	P	P			
Lapland longspur	P		P		
Horned lark			P		

Species	Valemount Flats	Columbia Reach Isl.	Bush Arm and Delta	Other Areas	Total
Mammals					
Moose	S (R)	S (M)	S (R/M)		
Caribou			S (R)		
Deer		S (R)	S (R)		
Coyote		S (R)	S (R)		
Beaver	S (R)	S (M)			
Mink	S (R)	S (R)			
Otter	S (A)	S (M)			
Chipmunk	1				1

S = Sign of species observed (tracks or scats)
(A) = Abundant sign
(M) = Moderate amount of sign
(R) = Rare sign
P = Species present, but not counted

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1 Ground survey by Triton Environmental Consultants Ltd.

APPENDIX 3

Bird Observations in the Arrow Lakes Area, October 20, 21 and 22, 1988

3.1 Aquatic Bird Observations in the North-Arrow Area, October 20-21, 1988

3.2 Birds Observed in the Arrow Lake Narrows Area, October 21-22, 1988

APPENDIX 3.1

Aquatic Bird Observations in the North-Arrow Area, October 20-21, 1988[1]

Species	Number	% of Total
Loons	0	0
Grebes		
Western Grebe	6	tr.
Swans	0	0
Geese		
Canada Goose	724	
Snow goose	1	
	725	40
Mergansers		
Hooded	16	
Common	3	
	19	1
Diving Ducks		
Ring-necked duck	46	
Bufflehead	4	
Scaup sp.	3	
Ruddy duck	1	
Oldsquaw	1	
	55	3
Dabbling Ducks		
Mallard	417	
Pintail	10	
Green-winged teal	56	
American wigeon	305	
	788	44
Coots	212	12
TOTAL	1,805	100%

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[1] Ground survey by Envirocon

APPENDIX 3.2

Birds Observed in the Arrow Lake Narrows Area, October 21-22, 1988[1]

Species	Number	Habitat
Common loon	14+	Open water of reservoir
Western grebe	34	Open water of reservoir
Red-necked grebe	9	Open water of reservoir
Canada goose	442	Shoreline at Slewiskin Cr. (2) and Arrow Park (65); Edgewood farms (375)
White-fronted goose	3	Arrow Park mudflats
Mallard	71	Shoreline (Fauquier and Edgewood)
Unidentified dabblers	15	Flats at Fairhurst Cr.
Bufflehead	6	Reservoir at Fauquier
Comm. merganser	2	Reservoir at Edgewood
Coot	1	Nakusp shoreline
Great-blue heron	tracks	Stream shoreline at Edgewood
Ring-billed gulls	2	Golf course at Fauquier
Bonaparte gull	4	Reservoir at Fauquier
Unidentified gulls	10+	Flying over the reservoir
Bald eagle	3 (Ad)	Perched at Burton and Arrow Park

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[1] Ground survey by Envirocon

APPENDIX 4

Medium Energy Load Scenario Summary Tables and Hydrographs

4.1 Base Case (Medium Load)
4.2 Regime 1 (Medium Load)
4.3 Differences: Regime 1 (Medium Load) Compared to Base Case (Medium Load)
4.4 Regime 2 (Medium Load)
4.5 Differences: Regime 2 (Medium Load) Compared to Base Case (Medium Load)

APPENDIX 4.1

Base Case (Medium Load)

Table A4.1.1 Summary table of median (50% exceedance) elevations, Mica Reservoir, Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	2455.6	2453.6	2447.5	2428.6	2417.6	2412.2	2398.8	2396.9	2398.8	2410.5	2441.9	2470.8	2471.8	2472.0	2433.9	75.1	2472.0	14	2395.9	8
1990	2468.1	2462.5	2456.3	2440.6	2428.8	2423.0	2410.5	2407.1	2406.8	2420.1	2446.4	2471.8	2473.8	2474.5	2442.4	67.7	2474.5	14	2405.3	9
1991	2468.1	2462.2	2455.1	2440.3	2427.9	2420.9	2407.7	2402.2	2402.3	2416.9	2445.5	2471.6	2473.9	2473.1	2441.0	71.7	2473.9	13	2402.2	8
1992	2466.5	2459.5	2453.1	2440.9	2430.1	2422.3	2412.0	2407.4	2404.9	2418.4	2444.9	2471.7	2472.0	2472.4	2441.5	67.5	2472.4	14	2404.9	9
1993	2466.5	2458.3	2452.2	2439.5	2424.2	2412.2	2400.2	2392.6	2394.1	2411.1	2441.0	2466.9	2470.7	2471.9	2436.4	79.3	2471.9	14	2392.6	8
1994	2471.9	2470.0	2463.0	2451.1	2436.1	2423.8	2409.9	2403.2	2402.8	2417.3	2445.8	2469.9	2473.6	2475.0	2444.7	72.2	2475.0	14	2402.8	9
1995	2475.0	2473.1	2467.2	2455.2	2440.1	2426.8	2411.9	2404.1	2404.9	2419.1	2447.1	2469.9	2473.6	2475.0	2447.0	70.9	2475.0	1	2404.1	8
1996	2475.0	2473.1	2469.6	2455.9	2440.8	2427.6	2413.9	2405.9	2405.7	2419.5	2448.0	2469.9	2473.6	2475.0	2447.8	69.3	2475.0	1	2405.7	9
1997	2475.0	2473.1	2469.7	2456.4	2441.8	2429.0	2414.6	2407.7	2407.0	2419.5	2448.0	2469.9	2473.6	2475.0	2448.2	68.0	2475.0	1	2407.0	9
1998	2475.0	2473.1	2469.7	2456.2	2441.5	2428.5	2413.9	2405.9	2405.6	2418.8	2448.0	2469.9	2473.6	2475.0	2447.9	69.4	2475.0	1	2405.5	9
1999	2475.0	2473.1	2469.7	2456.3	2441.8	2428.6	2414.4	2407.4	2406.6	2419.5	2448.3	2469.9	2473.6	2475.0	2448.2	68.4	2475.0	1	2406.6	9
2000	2475.0	2473.1	2469.7	2456.6	2442.9	2429.6	2415.8	2409.6	2409.3	2422.5	2451.4	2469.9	2473.6	2475.0	2449.2	65.7	2475.0	1	2409.3	9
2001	2475.0	2473.1	2469.7	2456.6	2441.9	2429.2	2415.5	2407.8	2407.6	2419.7	2448.3	2469.9	2473.6	2475.0	2448.4	67.4	2475.0	1	2407.5	9
2002	2475.0	2473.1	2469.7	2456.4	2441.8	2429.0	2414.6	2407.7	2407.0	2421.8	2448.5	2469.9	2473.6	2475.0	2448.5	68.0	2475.0	1	2407.0	9
2003	2475.0	2473.1	2469.7	2456.6	2442.0	2429.3	2415.5	2407.7	2407.6	2422.1	2449.1	2469.9	2473.6	2475.0	2448.7	67.4	2475.0	1	2407.6	9
2004	2475.0	2473.1	2469.7	2456.6	2442.4	2429.6	2415.8	2408.6	2408.7	2422.5	2451.4	2469.9	2473.6	2475.0	2449.1	66.4	2475.0	1	2408.6	8
2005	2475.0	2473.1	2469.7	2456.6	2442.6	2429.6	2415.8	2408.6	2408.7	2421.9	2448.5	2469.9	2473.6	2475.0	2448.8	66.4	2475.0	1	2408.6	8
2006	2475.0	2473.1	2469.7	2457.6	2443.2	2430.0	2416.6	2409.6	2409.2	2424.4	2450.5	2469.9	2473.6	2475.0	2449.5	65.8	2475.0	1	2409.2	9
2007	2475.0	2473.1	2469.7	2457.6	2443.2	2430.1	2416.6	2409.6	2409.3	2421.9	2449.1	2469.9	2473.6	2475.0	2449.2	65.7	2475.0	1	2409.3	9
2008	2475.0	2473.1	2469.7	2459.1	2444.4	2431.1	2417.0	2410.0	2410.2	2422.3	2451.4	2469.9	2473.6	2475.0	2449.8	65.0	2475.0	1	2410.0	8
AVG	2472.3	2469.5	2465.0	2451.7	2437.8	2426.1	2412.6	2406.0	2405.9	2419.5	2447.7	2470.1	2473.3	2474.4						
RNG	19.4	19.5	22.2	30.5	26.8	18.9	18.2	17.4	16.1	13.9	10.4	4.9	3.2	3.1						
SDEV	5.0	6.3	7.5	8.6	7.7	5.6	5.1	4.4	3.9	3.5	2.8	1.0	0.8	1.1						
FMAX	2475.0	2473.1	2469.7	2459.1	2444.4	2431.1	2417.0	2410.0	2410.2	2424.4	2451.4	2471.8	2473.9	2475.0						
FMIN	2455.6	2453.6	2447.5	2428.6	2417.6	2412.2	2398.8	2392.6	2394.1	2410.5	2441.0	2466.9	2470.7	2471.9						
MXYR	1995	1995	1997	2008	2008	2008	2008	2008	2008	2006	2000	1990	1991	1994						
MNYR	1989	1989	1989	1989	1989	1989	1989	1993	1993	1989	1993	1993	1993	1993						

Figure A4.1.1 Maximum, mean and minimum median monthly hydrograph of elevations, Mica Reservoir, Base Case (Medium Load)

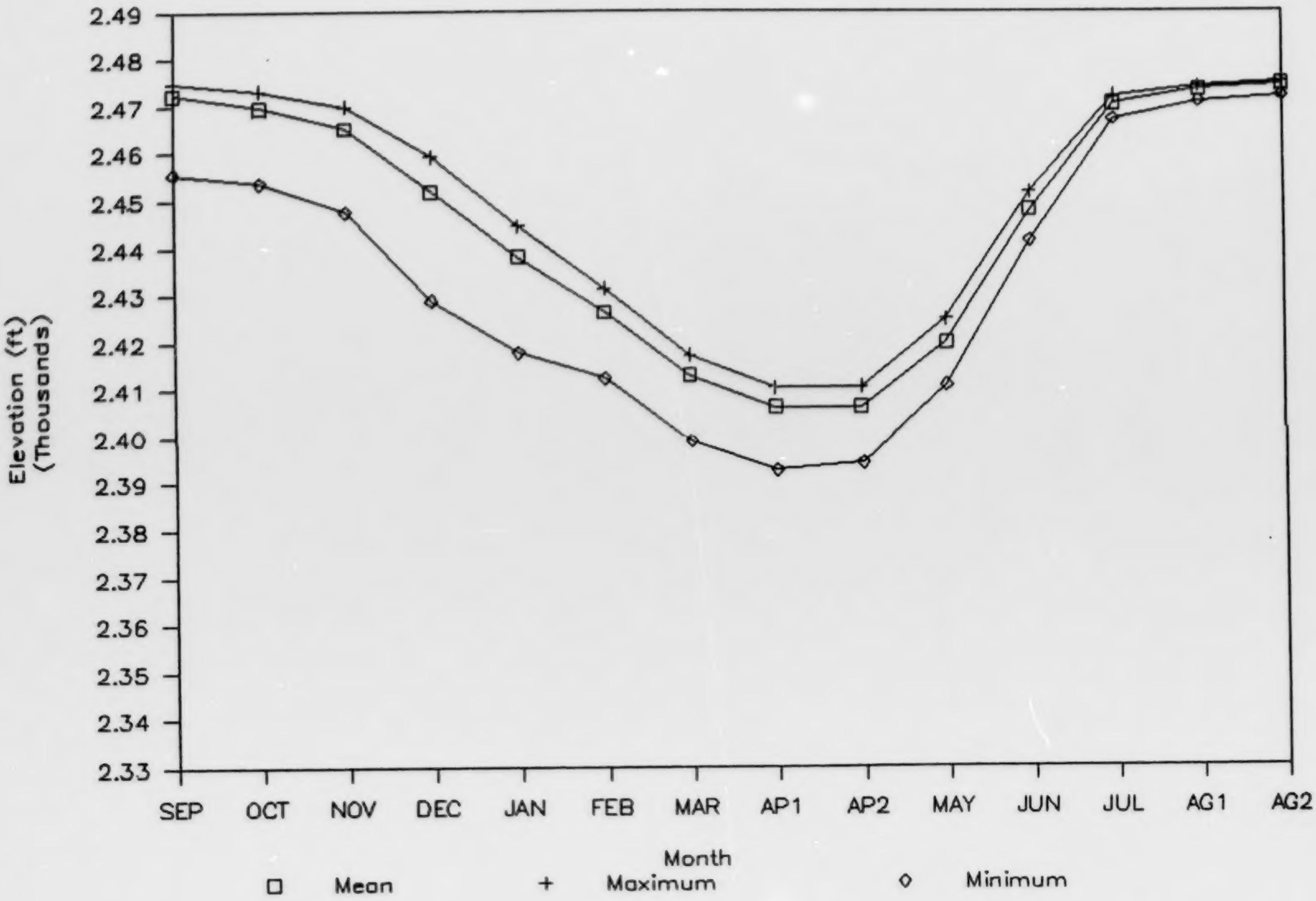


Table A4.1.2 Summary table of median (50% exceedance) outflows, Mica Reservoir, Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	20518.0	14350.0	17195.0	34000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	10000.0	21633.0	34578.0	33623.6	18541.5	24578.0	34578.0	13	10000.0	9
1990	26438.0	17792.0	19192.0	27456.0	26000.0	21601.0	17000.0	15000.0	10000.0	10000.0	10000.0	26304.0	37439.0	33564.0	20815.4	27439.0	37439.0	13	10000.0	9
1991	27102.0	19091.0	18332.0	27000.0	26400.0	22632.0	20000.0	15000.0	10000.0	10000.0	10000.0	26947.0	37295.0	37706.0	21458.7	27706.0	37706.0	14	10000.0	9
1992	29938.0	19996.0	18604.0	23000.0	21749.0	18549.0	18000.0	18000.0	18000.0	10000.0	10000.0	27314.0	40639.0	34108.0	21043.6	30639.0	40639.0	13	10000.0	10
1993	30228.0	19150.0	15420.0	27000.0	27000.0	25000.0	22812.0	27000.0	10000.0	10000.0	10000.0	23975.0	32576.0	32037.0	21782.6	22576.0	32576.0	13	10000.0	9
1994	21098.0	14750.0	14918.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	32576.0	32037.0	20881.0	22576.0	32576.0	13	10000.0	9
1995	20838.0	14750.0	14918.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	24231.0	32996.0	32037.0	20646.1	22996.0	32996.0	13	10000.0	9
1996	20838.0	15080.0	14898.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28018.0	33006.0	32269.0	20997.6	23006.0	33006.0	13	10000.0	9
1997	21038.0	15420.0	14277.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	26028.0	32996.0	32037.0	20815.0	22996.0	32996.0	13	10000.0	9
1998	21038.0	15080.0	14698.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28050.0	32996.0	31573.0	21037.5	22996.0	32996.0	13	10000.0	9
1999	21038.0	15310.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	32996.0	32457.0	20897.7	22996.0	32996.0	13	10000.0	9
2000	20518.0	15080.0	14028.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30960.0	33006.0	32457.0	20734.8	23006.0	33006.0	13	10000.0	9
2001	21238.0	14750.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	32996.0	32037.0	20850.2	22996.0	32996.0	13	10000.0	9
2002	21038.0	15080.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28877.0	32996.0	32037.0	21017.5	22996.0	32996.0	13	10000.0	9
2003	21038.0	14750.0	13989.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	33006.0	32037.0	20816.5	23006.0	33006.0	13	10000.0	9
2004	20518.0	15080.0	13989.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30677.0	33006.0	32560.0	20712.3	23006.0	33006.0	13	10000.0	9
2005	21038.0	14750.0	13989.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28975.0	32996.0	32457.0	20581.5	22996.0	32996.0	13	10000.0	9
2006	21038.0	14750.0	13061.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30173.0	33406.0	32560.0	20625.4	23406.0	33406.0	13	10000.0	9
2007	21098.0	15310.0	14198.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28975.0	32996.0	32269.0	20642.8	22996.0	32996.0	13	10000.0	9
2008	21038.0	15080.0	14198.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30876.0	33406.0	32519.0	20884.5	23406.0	33406.0	13	10000.0	9
AVG	22433.7	15770.0	15124.9	25672.8	26359.3	23647.3	21990.6	24750.0	10400.0	10000.0	10000.0	27540.7	33895.4	32719.1						
RNG	9710.0	5646.0	6131.0	12000.0	5964.0	14835.0	6000.0	12000.0	8000.0	0.0	0.0	9327.0	8063.0	6133.0						
SDEV	3175.4	1717.7	1746.7	3077.8	1721.2	3570.0	2123.3	4655.2	1788.9	0.0	0.0	2421.2	2098.3	1329.8						
FMAX	30228.0	19996.0	19192.0	34000.0	27000.0	25000.0	23000.0	27000.0	18000.0	10000.0	10000.0	30960.0	40639.0	37706.0						
FMIN	20518.0	14350.0	13061.0	22000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	10000.0	21633.0	32576.0	31573.0						
MXYR	1993	1992	1990	1989	1993	1993	1994	1993	1992	1989	1989	2000	1992	1991						
MNYR	1989	1989	2006	2000	1989	1989	1989	1989	1989	1989	1989	1989	1993	1998						

Figure A4.1.2 Maximum, mean and minimum median monthly hydrograph of outflows, Mica Reservoir, Base Case (Medium Load)

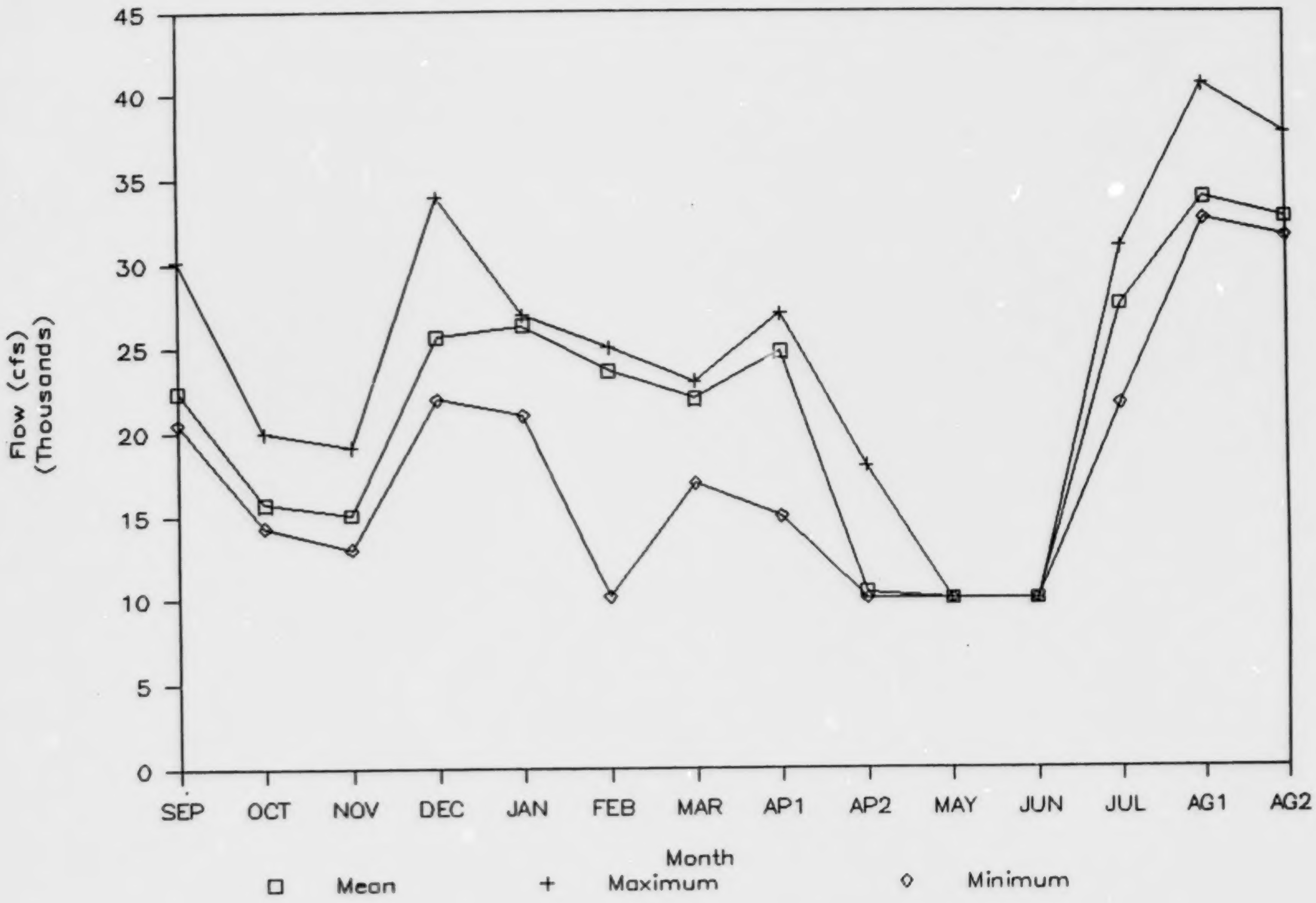


Table A4.1.3 Summary table of median (50% exceedance) elevations, Arrow Lakes Reservoir, Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	1444.0	1441.5	1438.1	1433.4	1408.9	1399.2	1399.1	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.3	44.9	1444.0	1	1399.1	7
1990	1444.0	1441.9	1438.9	1431.7	1406.6	1396.8	1396.2	1399.9	1399.9	1414.6	1435.3	1444.0	1444.0	1444.0	1424.5	47.8	1444.0	1	1396.2	7
1991	1444.0	1441.9	1439.3	1433.3	1408.6	1400.1	1398.2	1399.9	1399.9	1414.9	1435.8	1444.0	1444.0	1444.0	1425.3	45.8	1444.0	1	1398.2	7
1992	1444.0	1441.9	1440.0	1433.0	1407.0	1398.2	1396.6	1399.5	1399.9	1415.2	1437.0	1444.0	1444.0	1444.0	1425.1	47.4	1444.0	1	1396.6	7
1993	1444.0	1441.9	1439.3	1435.1	1407.9	1400.2	1399.5	1399.9	1401.4	1414.6	1435.3	1444.0	1444.0	1444.0	1425.5	44.5	1444.0	1	1399.5	7
1994	1443.7	1440.5	1439.9	1436.2	1410.6	1400.7	1399.9	1399.9	1399.9	1414.6	1435.7	1444.0	1444.0	1444.0	1425.8	44.1	1444.0	12	1399.9	7
1995	1443.5	1440.5	1440.1	1436.2	1409.9	1400.5	1398.8	1399.9	1400.6	1414.6	1435.6	1444.0	1444.0	1444.0	1425.7	45.2	1444.0	12	1398.8	7
1996	1443.6	1440.9	1440.8	1436.2	1412.3	1404.0	1399.9	1399.9	1399.9	1413.0	1435.9	1444.0	1444.0	1444.0	1426.2	44.1	1444.0	12	1399.9	7
1997	1443.7	1441.5	1440.6	1436.2	1411.0	1402.5	1399.9	1399.9	1400.7	1413.2	1435.6	1444.0	1444.0	1444.0	1426.0	44.1	1444.0	12	1399.9	7
1998	1443.7	1441.0	1439.5	1435.3	1409.3	1400.2	1399.6	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.6	44.4	1444.0	12	1399.6	7
1999	1443.8	1441.9	1439.8	1435.4	1410.2	1402.0	1399.9	1399.9	1403.3	1415.2	1437.3	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	12	1399.9	7
2000	1443.9	1441.9	1441.6	1436.2	1412.8	1403.7	1399.9	1399.9	1401.8	1415.2	1435.3	1444.0	1444.0	1444.0	1426.6	44.1	1444.0	12	1399.9	7
2001	1443.7	1441.2	1441.1	1436.2	1412.3	1403.7	1399.9	1399.9	1401.2	1415.2	1435.4	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	12	1399.9	7
2002	1443.8	1441.3	1439.9	1435.1	1410.5	1400.7	1399.9	1399.9	1403.4	1415.2	1437.0	1444.0	1444.0	1444.0	1426.1	44.1	1444.0	12	1399.9	7
2003	1443.8	1441.6	1440.7	1436.2	1412.3	1404.4	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	12	1399.9	7
2004	1443.8	1441.9	1441.6	1436.2	1413.5	1404.5	1399.9	1399.9	1401.5	1415.2	1437.3	1444.0	1444.0	1444.0	1426.9	44.1	1444.0	12	1399.9	7
2005	1443.8	1441.7	1441.6	1436.2	1413.1	1405.0	1399.9	1399.9	1403.2	1415.2	1437.5	1444.0	1444.0	1444.0	1427.0	44.1	1444.0	12	1399.9	7
2006	1443.8	1441.9	1441.8	1436.2	1413.8	1406.7	1399.9	1399.9	1403.9	1415.3	1435.6	1444.0	1444.0	1444.0	1427.1	44.1	1444.0	12	1399.9	7
2007	1443.8	1441.9	1441.6	1436.2	1411.1	1402.1	1399.9	1399.9	1403.4	1415.2	1436.1	1444.0	1444.0	1444.0	1426.5	44.1	1444.0	12	1399.9	7
2008	1443.9	1441.0	1442.1	1436.2	1413.4	1403.6	1399.4	1399.9	1401.5	1415.2	1435.5	1444.0	1444.0	1444.0	1426.7	44.5	1444.0	12	1399.4	7
AVG	1443.8	1441.6	1440.4	1435.3	1410.8	1401.9	1399.3	1399.9	1401.4	1414.9	1436.1	1444.0	1444.0	1444.0						
RNG	0.5	1.4	4.0	4.5	7.2	9.9	3.7	0.4	4.0	2.3	2.2	0.0	0.0	0.0						
SDEV	0.1	0.5	1.1	1.4	2.2	2.5	1.1	0.1	1.5	0.7	0.8	0.0	0.0	0.0						
FMAX	1444.0	1441.9	1442.1	1436.2	1413.8	1406.7	1399.9	1399.9	1403.9	1415.3	1437.5	1444.0	1444.0	1444.0						
FMIN	1443.5	1440.5	1438.1	1431.7	1406.6	1396.8	1396.2	1399.5	1399.9	1413.0	1435.3	1444.0	1444.0	1444.0						
MXYR	1989	1989	2008	1994	2006	2006	1994	1989	2006	2006	2005	1989	1989	1989						
MNYR	1995	1994	1989	1990	1990	1990	1990	1992	1989	1996	1990	1989	1989	1989						

Figure A4.1.3 Maximum (crosses), mean (squares) and minimum (diamonds) values of the median (50% exceedance) hydrograph of elevations, Arrow Lakes Reservoir, Base Case (Medium Load)

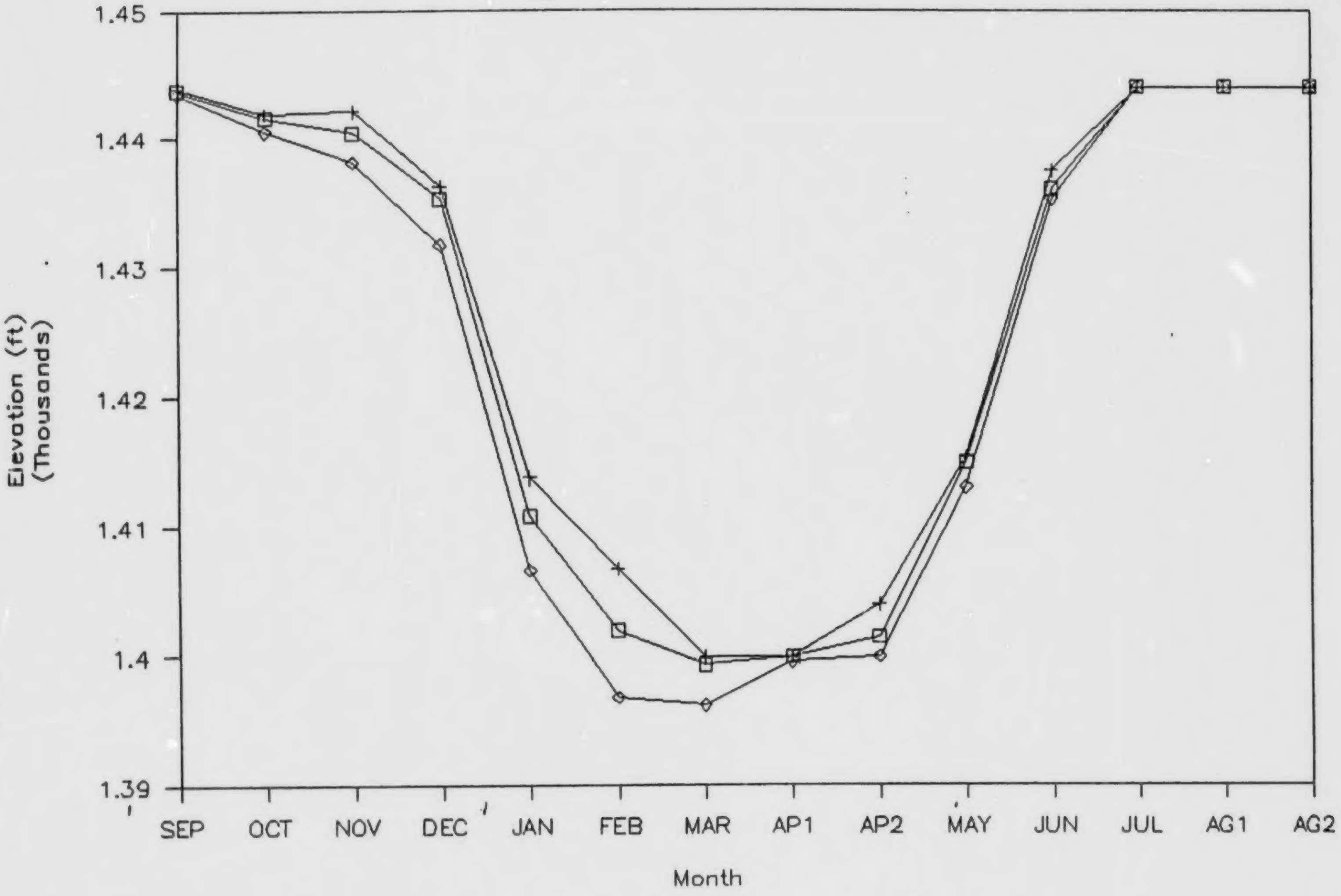
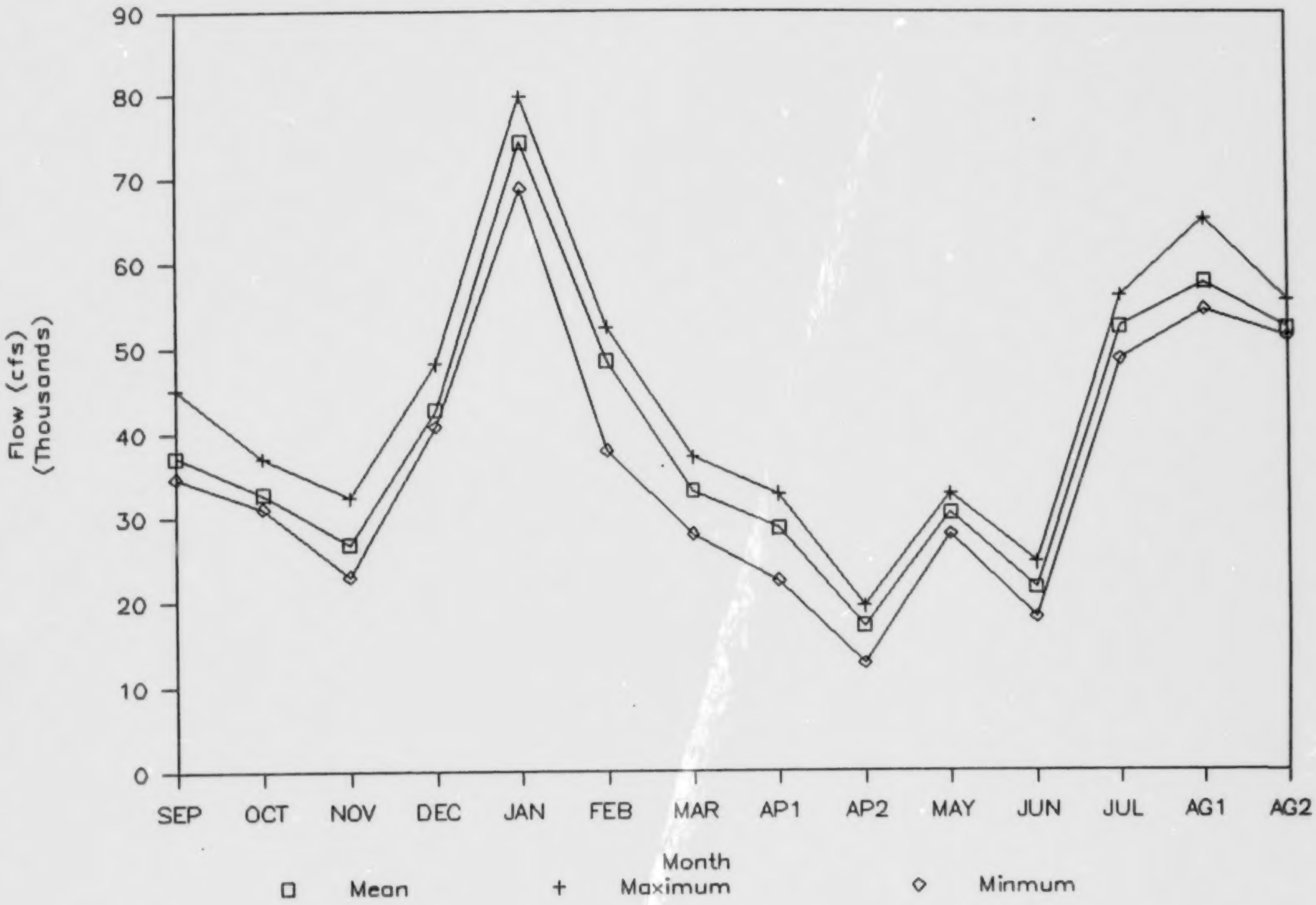


Table A4.1.4 Summary table of median (50% exceedance) outflows, Arrow Lakes Reservoir, Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	34978.0	33279.0	32430.0	48234.0	69750.0	38068.0	28057.0	22886.0	12796.0	27982.0	21077.0	48638.0	60493.0	51811.0	38840.5	56954.0	69750.0	5	12795.0	9
1990	41702.0	34970.0	32386.0	48282.0	70973.0	43469.0	28219.0	22486.0	14855.0	28903.0	22367.0	49277.0	62234.0	52920.0	39733.6	56118.0	70973.0	5	14855.0	9
1991	42976.0	34919.0	31064.0	46603.0	73113.0	43613.0	31168.0	22486.0	15129.0	28903.0	22370.0	54004.0	60493.0	55492.0	40461.1	57984.0	73113.0	5	15129.0	9
1992	44903.0	37105.0	30667.0	44046.0	69121.0	41560.0	31330.0	24470.0	17797.0	28903.0	21367.0	51073.0	65172.0	53813.0	40058.4	51324.0	69121.0	5	17797.0	9
1993	45257.0	36632.0	28795.0	42730.0	78519.0	44281.0	30900.0	27398.0	13740.0	29541.0	22151.0	51157.0	54629.0	52652.0	40347.7	64779.0	78519.0	5	13740.0	9
1994	36966.0	33272.0	26521.0	41805.0	76078.0	47359.0	32203.0	29486.0	17058.0	30102.0	18166.0	51513.0	54629.0	51282.0	39184.4	59020.0	76078.0	5	17058.0	9
1995	36455.0	32784.0	26329.0	41963.0	79692.0	46992.0	32316.0	28470.0	17846.0	30421.0	19476.0	50795.0	56677.0	51797.0	39551.5	61846.0	79692.0	5	17846.0	9
1996	36227.0	32522.0	26135.0	41763.0	71505.0	51721.0	34718.0	30837.0	19487.0	32206.0	19476.0	55971.0	54629.0	51891.0	40055.5	52029.0	71505.0	5	19476.0	11
1997	36304.0	33373.0	26552.0	42017.0	76077.0	51721.0	32931.0	29486.0	17846.0	32318.0	18166.0	51157.0	58603.0	52870.0	40001.5	58231.0	76077.0	5	17846.0	9
1998	36013.0	32638.0	27391.0	42475.0	78067.0	51721.0	32417.0	29486.0	17846.0	32524.0	22306.0	50795.0	57262.0	51650.0	40372.4	60221.0	78067.0	5	17846.0	9
1999	36156.0	32177.0	26229.0	42288.0	74599.0	51488.0	34718.0	29486.0	17347.0	31163.0	19983.0	51157.0	58492.0	51642.0	39870.1	57252.0	74599.0	5	17347.0	9
2000	34728.0	31654.0	25347.0	41734.0	74859.0	52529.0	35800.0	32870.0	17877.0	31148.0	24286.0	55971.0	58685.0	53486.0	40792.9	56982.0	74859.0	5	17877.0	9
2001	35071.0	31600.0	25890.0	41703.0	76930.0	51721.0	34718.0	31797.0	17877.0	29777.0	21282.0	51157.0	54629.0	51395.0	39808.2	59053.0	76930.0	5	17877.0	9
2002	36203.0	32258.0	26739.0	42848.0	76139.0	46105.0	32426.0	29486.0	17347.0	30509.0	22529.0	52654.0	54459.0	51630.0	39579.3	58792.0	76139.0	5	17347.0	9
2003	34726.0	31279.0	24463.0	41810.0	74948.0	51825.0	35261.0	29486.0	17347.0	32838.0	22306.0	51421.0	58191.0	51530.0	39929.5	57601.0	74948.0	5	17347.0	9
2004	34920.0	31461.0	23854.0	41627.0	72960.0	51721.0	37191.0	32870.0	17877.0	30124.0	23518.0	55971.0	55339.0	52870.0	40235.4	55083.0	72960.0	5	17877.0	9
2005	35815.0	31184.0	24361.0	41200.0	73907.0	51721.0	34718.0	31284.0	19100.0	30262.0	22078.0	52513.0	54459.0	51642.0	39666.8	54807.0	73907.0	5	19100.0	9
2006	34808.0	31156.0	23021.0	40894.0	68900.0	49887.0	35067.0	32698.0	17877.0	32150.0	24663.0	51338.0	56352.0	51642.0	39264.0	51023.0	68900.0	5	17877.0	9
2007	36121.0	31597.0	25084.0	41763.0	78067.0	51721.0	34471.0	29486.0	17846.0	30689.0	22529.0	56134.0	58683.0	51282.0	40568.7	60221.0	78067.0	5	17846.0	9
2008	35121.0	31366.0	24172.0	41535.0	73095.0	52529.0	35735.0	29486.0	17877.0	30605.0	21790.0	55849.0	59715.0	52690.0	40140.1	55218.0	73095.0	5	17877.0	9
AVG	37272.5	32861.7	26871.5	42866.0	74365.0	48587.6	33218.2	28822.0	17138.6	30557.4	21594.3	52427.3	57691.3	52299.4						
RNG	10531.0	5949.0	9409.0	7388.0	10792.0	14461.0	9134.0	10384.0	6691.0	4856.0	6497.0	7496.0	10713.0	4210.0						
SDEV	3430.9	1771.4	2796.2	2210.3	3187.0	4353.7	2459.3	3300.0	1690.9	1360.1	1782.9	2368.7	2965.0	1064.0						
FMAX	45257.0	37105.0	32430.0	48282.0	79692.0	52529.0	37191.0	32870.0	19487.0	32838.0	24663.0	56134.0	65172.0	55492.0						
FMIN	34726.0	31156.0	23021.0	40894.0	68900.0	38068.0	28057.0	22406.0	12796.0	27982.0	18166.0	48638.0	54459.0	51282.0						
MXYR	1993	1992	1989	1990	1995	2000	2004	2000	1996	2003	2006	2007	1992	1991						
MNYR	2003	2006	2006	2006	2006	1989	1989	1990	1989	1989	1994	1989	2002	1994						

Figure A4.1.4 Maximum, mean and minimum median monthly hydrograph of outflows, Arrow Lakes Reservoir, Base Case (Medium Load)



APPENDIX 4.2

Regime 1 (Medium Load)

Table A4.2.1 Summary table of median (50% exceedance) elevations, Mica Reservoir, Regime 1 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	2455.6	2453.6	2447.5	2428.6	2417.6	2412.2	2398.0	2396.9	2398.0	2410.5	2441.9	2470.8	2471.8	2472.0	2433.9	75.1	2472.0	14	2396.9	8
1990	2468.1	2460.0	2448.7	2429.9	2416.8	2413.0	2403.9	2400.0	2399.9	2413.2	2443.3	2469.7	2470.7	2471.3	2436.5	71.4	2471.3	14	2399.9	9
1991	2465.1	2458.3	2446.9	2427.7	2413.0	2406.2	2396.9	2393.3	2393.8	2407.8	2441.0	2466.6	2469.1	2469.2	2432.7	75.9	2469.2	14	2393.3	8
1992	2463.2	2456.7	2444.4	2427.2	2412.1	2404.0	2391.3	2387.5	2383.3	2401.0	2433.0	2459.2	2461.4	2463.1	2428.3	79.9	2463.2	1	2383.3	9
1993	2456.2	2450.4	2442.8	2424.0	2404.8	2388.8	2374.5	2366.8	2367.0	2388.7	2425.2	2451.9	2454.8	2453.5	2419.0	89.4	2456.2	1	2366.8	8
1994	2447.1	2440.1	2432.8	2416.7	2399.5	2384.2	2363.5	2354.9	2354.0	2381.0	2414.6	2439.5	2444.2	2443.6	2409.8	93.1	2447.1	1	2354.0	9
1995	2438.7	2432.6	2424.3	2410.8	2392.7	2378.8	2363.0	2354.5	2353.8	2378.2	2416.1	2440.4	2443.6	2443.7	2406.1	89.9	2443.7	14	2353.8	9
1996	2435.8	2429.8	2425.1	2411.9	2398.2	2382.7	2367.5	2356.9	2356.9	2381.4	2415.3	2441.2	2445.7	2447.2	2407.7	90.3	2447.2	14	2356.9	8
1997	2438.8	2435.4	2428.7	2415.8	2402.0	2390.0	2374.1	2364.9	2365.3	2382.7	2419.8	2448.1	2450.6	2452.0	2412.7	87.1	2452.0	14	2364.9	8
1998	2447.3	2442.2	2437.3	2424.2	2407.8	2394.6	2381.8	2373.9	2374.4	2394.6	2429.6	2455.6	2458.0	2458.3	2420.6	84.4	2458.3	14	2373.9	8
1999	2454.0	2449.7	2442.7	2430.3	2411.6	2399.9	2387.9	2379.9	2381.4	2399.6	2434.2	2457.6	2460.8	2461.5	2425.8	81.6	2461.5	14	2379.9	8
2000	2456.4	2448.9	2441.8	2431.3	2414.8	2403.5	2394.6	2387.0	2387.1	2405.6	2439.6	2463.5	2465.6	2465.9	2429.4	78.9	2465.9	14	2387.0	8
2001	2459.0	2451.7	2442.7	2430.7	2410.7	2397.2	2384.9	2376.9	2379.2	2396.9	2429.5	2454.8	2457.2	2457.3	2424.4	82.1	2459.0	1	2376.9	8
2002	2451.3	2445.3	2437.4	2424.7	2406.0	2391.6	2377.8	2369.2	2370.5	2391.3	2423.0	2449.3	2452.1	2451.3	2418.3	82.9	2452.1	13	2369.2	8
2003	2445.9	2441.5	2435.0	2423.4	2407.5	2397.7	2387.4	2379.7	2381.8	2399.7	2432.7	2456.9	2459.5	2460.0	2422.3	80.3	2460.0	14	2379.7	8
2004	2452.4	2447.1	2443.0	2430.1	2412.9	2400.2	2391.1	2384.1	2385.3	2404.3	2439.6	2460.7	2463.0	2463.9	2427.5	79.8	2463.9	14	2384.1	8
2005	2455.8	2449.6	2442.3	2426.7	2410.3	2396.8	2384.3	2376.4	2377.9	2400.2	2430.8	2455.9	2458.1	2457.8	2424.0	81.7	2458.1	13	2376.4	8
2006	2450.7	2444.0	2437.2	2422.0	2405.9	2392.4	2379.5	2371.2	2373.0	2396.1	2426.8	2452.3	2455.7	2454.5	2419.5	84.5	2455.7	13	2371.2	8
2007	2448.1	2442.5	2436.7	2422.2	2406.0	2391.9	2381.3	2373.5	2373.0	2392.9	2426.4	2451.7	2454.7	2455.3	2419.0	82.3	2455.3	14	2373.0	9
2008	2448.3	2442.1	2435.2	2421.4	2407.5	2395.0	2386.0	2378.2	2377.6	2396.1	2428.7	2455.6	2459.8	2459.7	2421.1	82.2	2459.8	13	2377.6	9
AVG	2451.9	2446.1	2438.6	2424.0	2407.9	2396.0	2383.5	2376.3	2376.7	2396.1	2429.6	2455.1	2457.8	2458.1						
RNG	32.3	30.2	24.4	20.5	24.9	34.2	40.9	45.5	46.1	35.0	28.7	31.3	28.2	28.4						
SDEV	8.6	8.2	7.0	6.1	6.4	9.1	11.3	13.0	13.2	10.0	8.9	8.8	8.1	8.2						
FMAX	2468.1	2460.0	2448.7	2431.3	2417.6	2413.0	2403.9	2400.0	2399.9	2413.2	2443.3	2470.8	2471.8	2472.0						
FMIN	2435.8	2429.8	2424.3	2410.8	2392.7	2378.8	2363.0	2354.5	2353.8	2378.2	2414.6	2439.5	2443.6	2443.6						
MXYR	1990	1990	1990	2000	1989	1990	1990	1990	1990	1990	1990	1989	1989	1989						
MNYR	1996	1996	1995	1995	1995	1995	1995	1995	1995	1995	1994	1994	1995	1994						

Figure A4.2.1 Maximum, mean and minimum median monthly hydrograph of elevations, Mica Reservoir, Regime 1 (Medium Load)

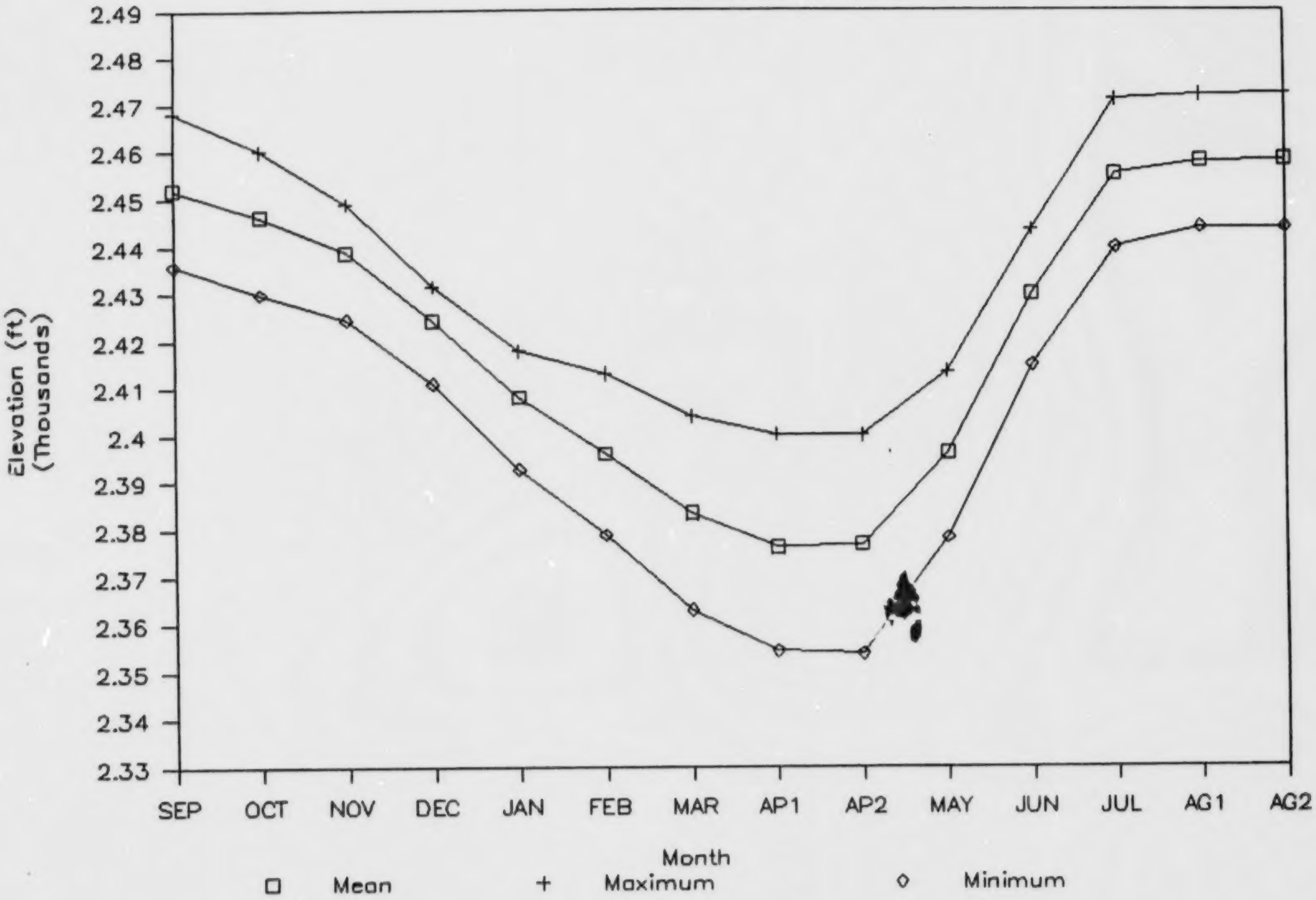


Table A4.2.2 Summary table of median (50% exceedance) outflows, Mica Reservoir, Regime 1 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	20518.0	14350.0	17195.0	34000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	10000.0	21633.0	34578.0	33623.0	18541.5	24578.0	34578.0	13	10000.0	9
1990	26438.0	24320.0	23327.0	32784.0	26000.0	22044.0	17000.0	15000.0	10000.0	10000.0	10000.0	26304.0	37439.0	33562.0	22184.8	27439.0	37439.0	13	10000.0	9
1991	31215.0	21740.0	20879.0	32016.0	24334.0	16631.0	20000.0	15000.0	10000.0	10000.0	10000.0	25944.0	36602.0	37089.0	21842.0	27089.0	37089.0	14	10000.0	9
1992	32000.0	23422.0	21953.0	25893.0	22943.0	15327.0	18000.0	18000.0	18000.0	10000.0	10000.0	23908.0	40639.0	33988.0	21563.3	30639.0	40639.0	13	10000.0	10
1993	32036.0	22339.0	20619.0	27072.0	27000.0	23202.0	18725.0	27000.0	10000.0	10000.0	7239.0	21219.0	34106.0	33717.0	21828.5	26867.0	34106.0	13	7239.0	11
1994	32237.0	22530.0	20506.0	27000.0	27000.0	25000.0	21788.0	24373.0	10000.0	10000.0	10000.0	22917.0	34777.0	33687.0	22533.0	24777.0	34777.0	13	10000.0	9
1995	29775.0	19150.0	19465.0	27000.0	27000.0	25000.0	18298.0	22390.0	10000.0	10000.0	8739.0	20962.0	34000.0	32984.0	21256.3	25261.0	34000.0	13	8739.0	11
1996	31500.0	19264.0	19619.0	27000.0	27000.0	24893.0	19897.0	22783.0	10000.0	10000.0	7279.0	21800.0	34577.0	33687.0	21564.6	27298.0	34577.0	13	7279.0	11
1997	29895.0	20178.0	16640.0	27000.0	27000.0	21385.0	19230.0	22000.0	10000.0	10000.0	10000.0	21800.0	35556.0	33717.0	21147.0	25556.0	35556.0	13	10000.0	9
1998	29390.0	18471.0	15300.0	27000.0	27000.0	23626.0	20916.0	22784.0	10000.0	10000.0	8721.0	21974.0	35393.0	33717.0	21112.1	26672.0	35393.0	13	8721.0	11
1999	30205.0	19680.0	14898.0	25829.0	26571.0	22521.0	20544.0	27000.0	10000.0	10000.0	10000.0	22808.0	34385.0	32699.0	21258.2	24385.0	34385.0	13	10000.0	9
2000	32237.0	20488.0	14277.0	22000.0	27000.0	21105.0	19450.0	27000.0	10000.0	10000.0	10000.0	26296.0	36629.0	33730.0	21377.7	26629.0	36629.0	13	10000.0	9
2001	32574.0	22272.0	15420.0	22000.0	27000.0	25000.0	21986.0	27000.0	10000.0	10000.0	10000.0	23764.0	36437.0	33871.0	21972.5	26437.0	36437.0	13	10000.0	9
2002	32036.0	21056.0	15528.0	24310.0	27000.0	24297.0	22401.0	26890.0	10000.0	10000.0	10000.0	22960.0	36255.0	33871.0	21931.3	26255.0	36255.0	13	10000.0	9
2003	31403.0	16750.0	14270.0	22000.0	23631.0	18062.0	18025.0	27000.0	10000.0	10000.0	10000.0	23975.0	35813.0	32659.0	20071.0	25813.0	35813.0	13	10000.0	9
2004	32690.0	21448.0	14898.0	22000.0	27000.0	20518.0	18511.0	27000.0	10000.0	10000.0	10000.0	25800.0	36825.0	35492.0	21460.3	26825.0	36825.0	13	10000.0	9
2005	33261.0	21787.0	17907.0	22000.0	27000.0	25000.0	19426.0	27000.0	10000.0	10000.0	10000.0	25114.0	35579.0	33773.0	22055.9	25579.0	35579.0	13	10000.0	9
2006	33291.0	20144.0	15510.0	22000.0	27000.0	23366.0	18804.0	25361.0	10000.0	10000.0	10000.0	25000.0	36629.0	33717.0	21497.4	26629.0	36629.0	13	10000.0	9
2007	32030.0	19150.0	15358.0	22000.0	27000.0	21793.0	20523.0	27000.0	10000.0	10000.0	10000.0	23721.0	36359.0	33149.0	21236.4	26359.0	36359.0	13	10000.0	9
2008	32238.0	20863.0	15420.0	22000.0	25510.0	24314.0	20838.0	25361.0	10000.0	10000.0	10000.0	25729.0	36629.0	33870.0	21653.5	26629.0	36629.0	13	10000.0	9
AVG	30848.8	20470.1	17449.4	25645.2	26051.3	21666.4	19572.1	23547.1	10400.0	10000.0	9598.9	23681.4	35960.4	33830.1						
RNG	12773.0	9970.0	9057.0	12000.0	5964.0	14835.0	5401.0	12000.0	8000.0	0.0	2761.0	5342.0	6639.0	4430.0						
SDEV	2912.3	2290.4	2842.9	3844.0	1715.1	3917.2	1573.7	4404.8	1788.9	0.0	889.6	1791.3	1499.0	958.7						
FMAX	33291.0	24320.0	23327.0	34000.0	27000.0	25000.0	22401.0	27000.0	18000.0	10000.0	10000.0	26304.0	40639.0	37089.0						
FMIN	20518.0	14350.0	14270.0	22000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	7239.0	20962.0	34000.0	32659.0						
MXYR	2006	1990	1990	1989	1993	1994	2002	1993	1992	1989	1989	1990	1992	1991						
MNYR	1989	1989	2003	2000	1989	1989	1989	1989	1989	1989	1993	1995	1995	2003						

Figure A4.2.2 Maximum, mean and minimum median monthly hydrograph of outflows, Mica Reservoir, Regime 1 (Medium Load)

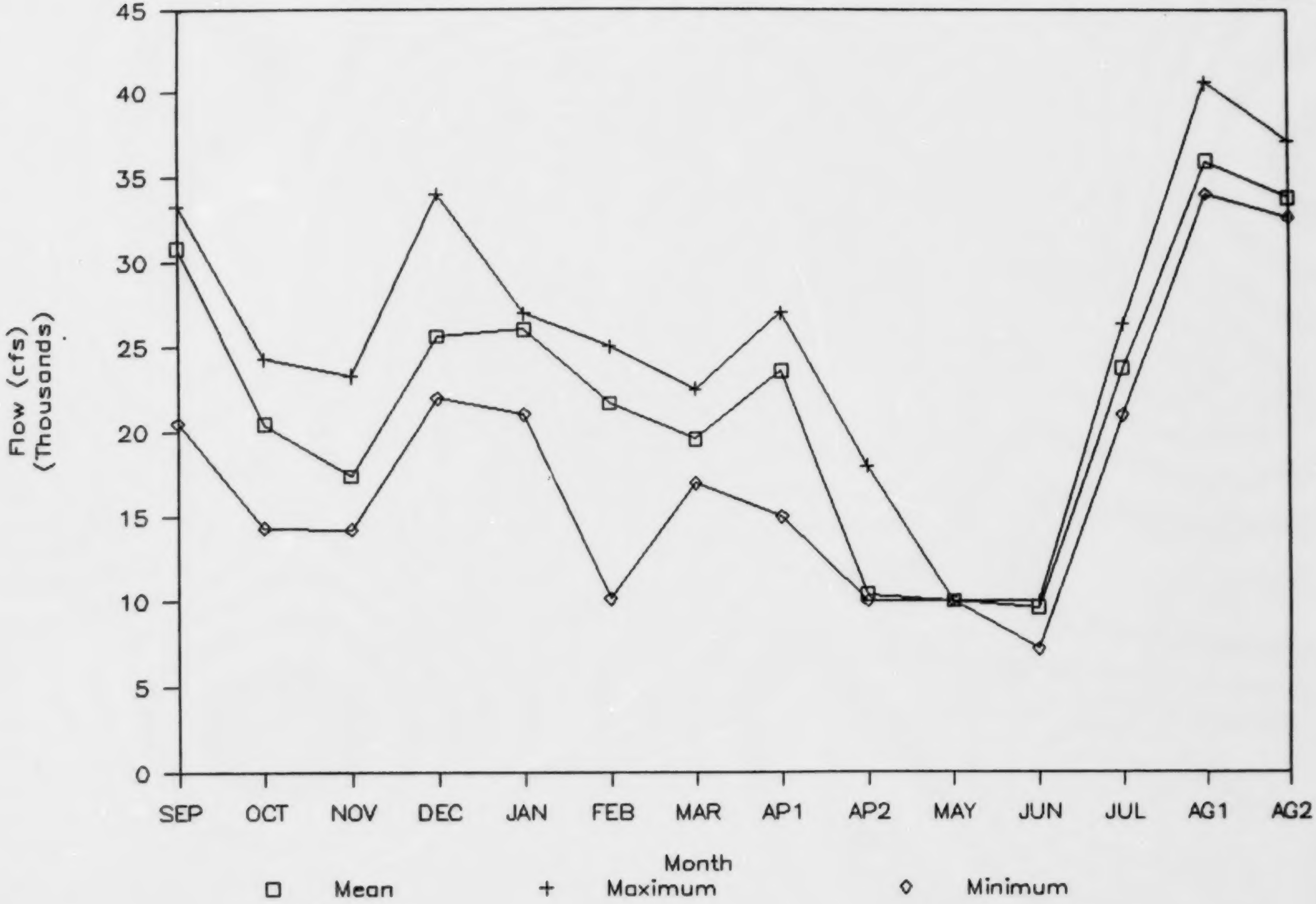


Table A4.2.3 Summary table of median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 1 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	1444.0	1441.9	1438.1	1433.4	1408.9	1399.2	1399.1	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.3	44.9	1444.0	1	1399.1	7
1990	1444.0	1441.9	1438.9	1431.8	1406.6	1396.8	1392.7	1398.7	1399.9	1414.6	1435.3	1444.0	1444.0	1444.0	1424.2	51.3	1444.0	1	1392.7	7
1991	1444.0	1441.9	1439.3	1433.4	1408.8	1400.6	1398.6	1399.9	1399.9	1415.2	1437.2	1444.0	1444.0	1444.0	1425.6	45.4	1444.0	1	1398.6	7
1992	1444.0	1441.9	1440.0	1433.0	1407.3	1397.8	1397.3	1399.7	1399.9	1415.2	1437.0	1444.0	1444.0	1444.0	1425.1	46.7	1444.0	1	1397.3	7
1993	1444.0	1441.9	1439.4	1435.2	1408.6	1401.2	1399.5	1399.9	1402.1	1415.2	1435.3	1444.0	1444.0	1444.0	1425.8	44.5	1444.0	1	1399.5	7
1994	1444.0	1441.9	1440.4	1436.2	1411.7	1402.5	1399.9	1399.9	1401.0	1415.2	1436.2	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	1	1399.9	7
1995	1444.0	1441.9	1441.2	1436.2	1410.5	1402.1	1398.9	1399.9	1402.8	1414.7	1435.6	1444.0	1444.0	1444.0	1426.2	45.1	1444.0	1	1398.9	7
1996	1444.0	1441.9	1441.3	1436.2	1413.3	1405.1	1399.9	1399.9	1402.9	1414.7	1436.1	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	1	1399.9	7
1997	1444.0	1441.9	1441.5	1436.2	1411.1	1403.5	1399.9	1399.9	1401.1	1414.6	1435.3	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	1	1399.9	7
1998	1444.0	1441.9	1439.4	1434.9	1409.7	1399.7	1399.9	1399.9	1401.7	1415.2	1437.3	1444.0	1444.0	1444.0	1425.9	44.3	1444.0	1	1399.7	6
1999	1444.0	1441.9	1440.1	1435.7	1410.7	1402.3	1399.9	1399.9	1403.4	1414.8	1437.5	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	1	1399.9	7
2000	1444.0	1442.0	1442.1	1436.2	1413.3	1404.4	1399.9	1399.9	1403.4	1415.2	1435.3	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	1	1399.9	7
2001	1444.0	1442.0	1442.1	1436.2	1412.3	1403.7	1399.9	1399.9	1402.9	1415.2	1436.1	1444.0	1444.0	1444.0	1426.7	44.1	1444.0	1	1399.9	7
2002	1444.0	1441.9	1440.0	1435.3	1411.2	1402.2	1399.9	1399.9	1403.4	1415.2	1437.4	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	1	1399.9	7
2003	1444.0	1441.9	1441.8	1436.2	1412.3	1404.5	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.9	44.1	1444.0	1	1399.9	7
2004	1444.0	1442.0	1442.1	1436.2	1414.3	1404.5	1399.9	1399.9	1401.8	1415.2	1437.3	1444.0	1444.0	1444.0	1427.0	44.1	1444.0	1	1399.9	7
2005	1444.0	1441.9	1442.1	1436.2	1413.3	1405.5	1399.9	1400.1	1403.4	1415.2	1437.5	1444.0	1444.0	1444.0	1427.1	44.1	1444.0	1	1399.9	7
2006	1444.0	1442.0	1442.1	1436.2	1414.4	1407.6	1399.9	1400.7	1403.9	1417.9	1436.1	1444.0	1444.0	1444.0	1427.5	44.1	1444.0	1	1399.9	7
2007	1444.0	1441.9	1442.1	1436.2	1412.2	1403.8	1399.9	1399.9	1403.4	1415.2	1436.1	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	1	1399.9	7
2008	1444.0	1442.1	1442.1	1436.2	1414.2	1404.5	1399.9	1399.9	1402.4	1415.2	1435.6	1444.0	1444.0	1444.0	1426.9	44.1	1444.0	1	1399.9	7
AVG	1444.0	1441.9	1440.8	1435.4	1411.2	1402.6	1399.2	1399.9	1402.1	1415.2	1436.4	1444.0	1444.0	1444.0						
RNG	0.0	0.2	4.0	4.4	7.8	10.8	7.2	2.0	4.0	3.3	2.2	0.0	0.0	0.0						
SDEV	0.0	0.1	1.3	1.4	2.3	2.7	1.7	0.3	1.4	0.7	0.9	0.0	0.0	0.0						
FMAX	1444.0	1442.1	1442.1	1436.2	1414.4	1407.6	1399.9	1400.7	1403.9	1417.9	1437.5	1444.0	1444.0	1444.0						
FMIN	1444.0	1441.9	1438.1	1431.8	1406.6	1396.8	1392.7	1398.7	1399.9	1414.6	1435.3	1444.0	1444.0	1444.0						
MXYR	1989	2008	2000	1994	2006	2006	1994	2006	2006	2006	1999	1989	1989	1989						
MNYR	1989	1989	1989	1990	1990	1990	1990	1990	1989	1990	1990	1989	1989	1989						

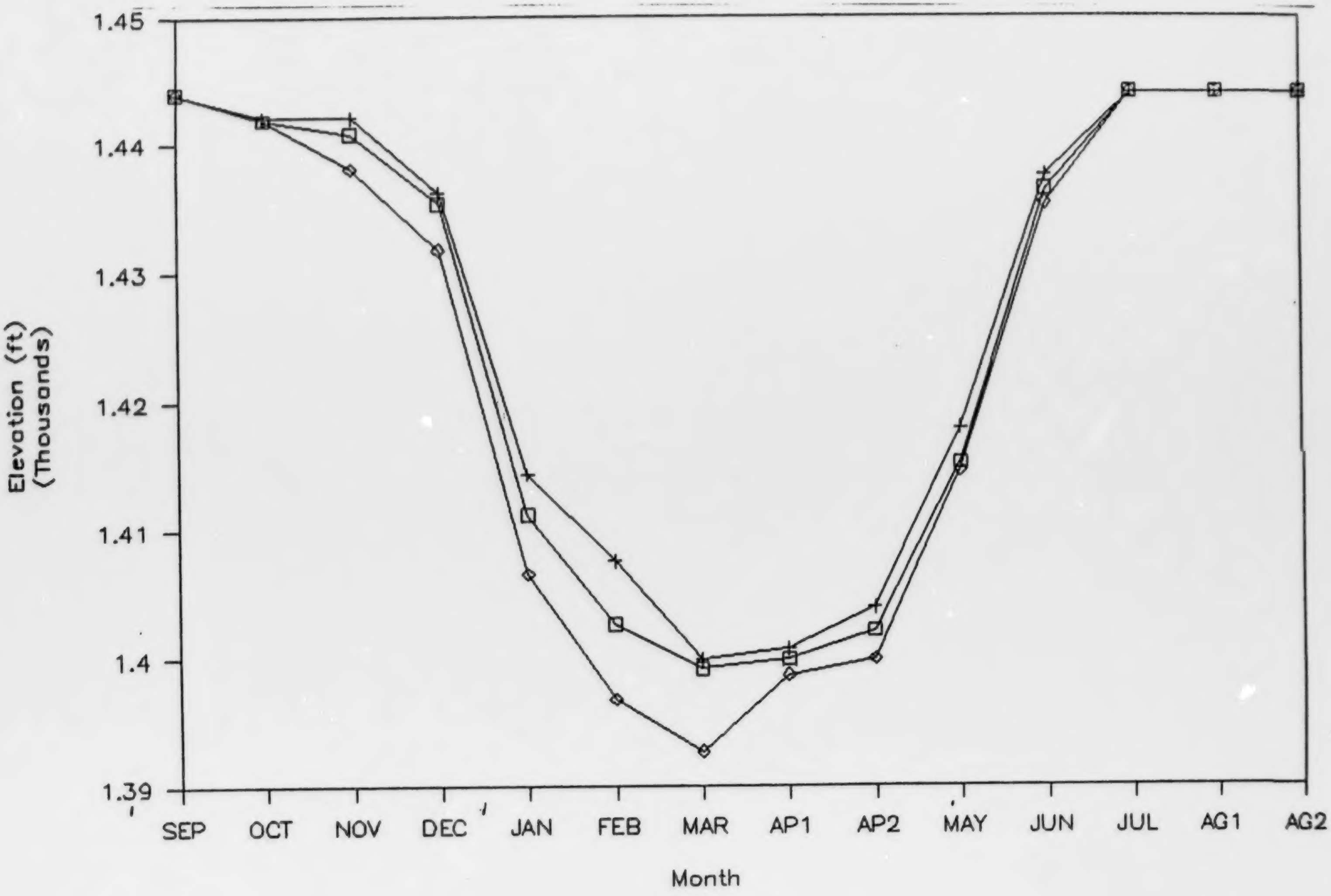
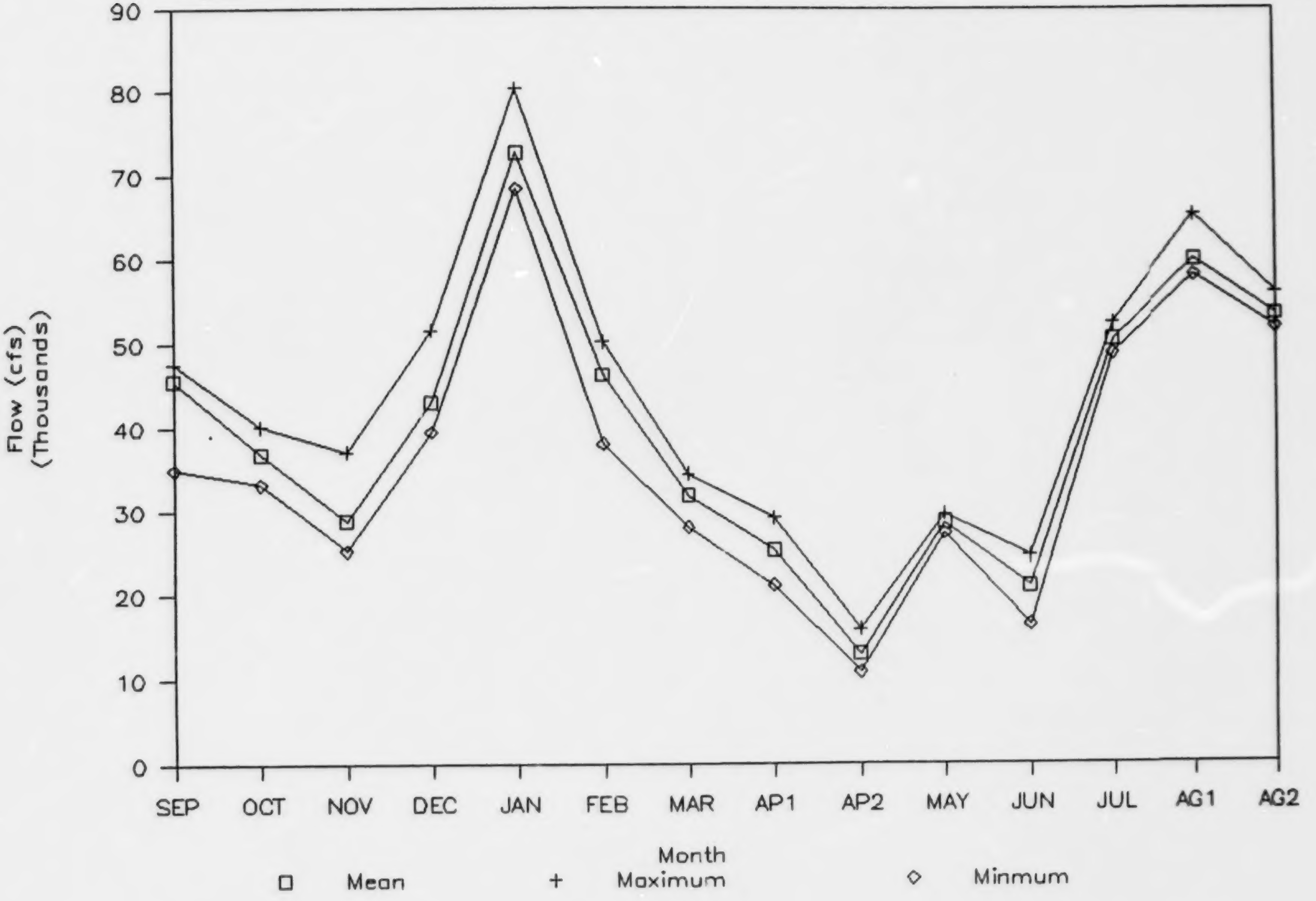


Figure A4.2.3 Maximum (crosses), mean (squares) and minimum (diamonds) values of the median (50% exceedance) hydrograph of elevations, Arrow Lakes Reservoir, Regime 1 (Medium Load)

Table A4.2.4 Summary table of median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 1 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MI	MIN	MT
1989	34978.0	33279.0	32430.0	48234.0	69750.0	38068.0	28057.0	22886.0	12796.0	27982.0	21077.0	48638.0	60493.0	51811.0	38040.5	56954.0	69750.0	5	12796.0	9
1990	41702.0	40162.0	37171.0	51676.0	70681.0	47586.0	29813.0	21962.0	13184.0	28903.0	22306.0	49273.0	63132.0	52870.0	41237.3	57497.0	70681.0	5	13184.0	9
1991	45259.0	37772.0	33600.0	48070.0	72715.0	45174.0	31049.0	21470.0	13282.0	28842.0	21926.0	51578.0	60493.0	55913.0	40963.7	59433.0	72715.0	5	13282.0	9
1992	46417.0	39497.0	32889.0	46374.0	71274.0	44768.0	30590.0	21155.0	15980.0	28058.0	21073.0	50448.0	65172.0	54162.0	40801.9	55294.0	71274.0	5	15980.0	9
1993	46209.0	38757.0	32726.0	45467.0	80428.0	46341.0	31596.0	25649.0	11095.0	28819.0	20986.0	49288.0	58762.0	54423.0	41298.5	69333.0	80428.0	5	11095.0	9
1994	47206.0	38539.0	30313.0	44110.0	75039.0	50137.0	32495.0	26166.0	11947.0	27325.0	18672.0	50795.0	57921.0	52601.0	40745.7	63092.0	75039.0	5	11947.0	9
1995	45222.0	36027.0	28385.0	43085.0	76933.0	46008.0	30320.0	23857.0	10826.0	27325.0	17541.0	48678.0	59057.0	52880.0	39402.8	66107.0	76933.0	5	10826.0	9
1996	45947.0	36026.0	28085.0	42606.0	70564.0	43450.0	34436.0	25758.0	13496.0	27933.0	18951.0	49164.0	58100.0	53662.0	39389.2	57068.0	70564.0	5	13496.0	9
1997	45998.0	35955.0	27391.0	42255.0	73100.0	43317.0	33770.0	25723.0	13397.0	29571.0	16415.0	49132.0	59082.0	53260.0	39386.3	59703.0	73100.0	5	13397.0	9
1998	45160.0	35231.0	28485.0	41734.0	76284.0	45698.0	29271.0	25762.0	12385.0	28819.0	20986.0	48909.0	59488.0	53025.0	39658.9	63899.0	76284.0	5	12385.0	9
1999	44501.0	36169.0	27254.0	41652.0	72177.0	45459.0	30722.0	25750.0	12328.0	28903.0	21130.0	48819.0	58778.0	52378.0	39283.6	59849.0	72177.0	5	12328.0	9
2000	46902.0	36965.0	25868.0	39912.0	71271.0	46166.0	34204.0	29103.0	15664.0	28903.0	24663.0	51338.0	61123.0	53926.0	40508.3	55607.0	71271.0	5	15664.0	9
2001	47692.0	38229.0	27391.0	39788.0	75538.0	48921.0	32398.0	26685.0	13503.0	28903.0	20504.0	50199.0	60389.0	53662.0	40556.9	62035.0	75538.0	5	13503.0	9
2002	46544.0	37144.0	28548.0	41734.0	75404.0	48413.0	31597.0	26271.0	11609.0	29571.0	21926.0	50698.0	58755.0	53662.0	40560.6	63795.0	75404.0	5	11609.0	9
2003	44970.0	33835.0	25330.0	39515.0	70830.0	46483.0	31805.0	25749.0	12368.0	29593.0	20986.0	51338.0	60212.0	51749.0	39143.7	58462.0	70830.0	5	12368.0	9
2004	47256.0	37251.0	25651.0	39845.0	70179.0	47223.0	34374.0	27973.0	13503.0	28851.0	22546.0	51377.0	59963.0	54471.0	40209.0	56676.0	70179.0	5	13503.0	9
2005	47692.0	38191.0	27375.0	41517.0	71161.0	47246.0	30525.0	27466.0	13512.0	27325.0	22546.0	52297.0	58000.0	53232.0	40198.3	57649.0	71161.0	5	13512.0	9
2006	47692.0	36483.0	25555.0	40105.0	68443.0	44282.0	32501.0	25750.0	12495.0	28903.0	22998.0	51258.0	58286.0	52915.0	39411.9	55948.0	68443.0	5	12495.0	9
2007	47314.0	35973.0	26936.0	42255.0	74072.0	50137.0	33259.0	24109.0	13409.0	28226.0	22206.0	51340.0	59581.0	52915.0	40560.4	60663.0	74072.0	5	13409.0	9
2008	47231.0	37120.0	25851.0	41403.0	70176.0	49957.0	32882.0	27565.0	13503.0	28846.0	20765.0	51486.0	60135.0	52940.0	40233.0	56673.0	70176.0	5	13503.0	9
AVG	45594.6	36930.6	28861.7	43066.9	72801.0	46241.7	31783.2	25340.4	13014.1	28580.1	21010.2	50302.6	59886.1	53322.9						
RNG	12714.0	6883.0	11841.0	12161.0	11985.0	12069.0	6379.0	7948.0	5154.0	2268.0	8248.0	3659.0	7251.0	4164.0						
SDEV	2884.0	1735.3	3269.7	3311.6	3005.0	2820.7	1766.7	2160.1	1269.1	715.9	1919.4	1192.0	1736.9	968.1						
FMAX	47692.0	40162.0	37171.0	51676.0	80428.0	50137.0	34436.0	29103.0	15980.0	29593.0	24663.0	52297.0	65172.0	55913.0						
FMIN	34978.0	33279.0	25330.0	39515.0	68443.0	38068.0	28057.0	21155.0	10826.0	27325.0	16415.0	48638.0	57921.0	51749.0						
MXYR	2001	1990	1990	1990	1993	1994	1996	2000	1992	2003	2000	2005	1992	1991						
MNYR	1989	1989	2003	2003	2006	1989	1989	1992	1995	1994	1997	1989	1994	2003						

Figure A4.2.4 Maximum, mean and minimum median monthly hydrograph of outflows, Arrow Lakes Reservoir, Regime 1 (Medium Load)



APPENDIX 4.3

Differences
Regime 1 (Medium Load) Compared to Base Case (Medium Load)

Table A4.3.1 Summary table of differences between median (50% exceedance) elevations, Mica Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	-2.5	-7.6	-10.7	-12.0	-10.0	-6.6	-7.1	-6.9	-6.9	-3.1	-2.1	-3.1	-3.2	-6.0	12.0	0.0	1	-12.0	5
1991	-3.0	-3.9	-8.2	-12.6	-14.9	-14.7	-10.8	-8.9	-8.5	-9.1	-4.5	-5.0	-4.8	-3.9	-8.3	11.9	-3.0	1	-14.9	5
1992	-3.3	-2.8	-8.7	-13.7	-18.0	-18.3	-20.7	-19.9	-21.6	-17.4	-11.9	-12.5	-10.6	-9.3	-13.2	18.8	-2.8	2	-21.6	9
1993	-10.3	-7.9	-9.4	-15.5	-19.4	-23.4	-25.7	-25.8	-27.1	-22.4	-15.9	-15.0	-15.9	-18.4	-17.4	19.2	-7.9	2	-27.1	9
1994	-24.8	-29.9	-30.2	-34.4	-36.6	-39.6	-46.4	-48.3	-48.8	-36.3	-31.2	-30.4	-29.4	-31.4	-34.9	24.0	-24.8	1	-48.8	9
1995	-36.3	-40.5	-42.9	-44.4	-47.4	-48.0	-48.9	-49.6	-51.1	-40.9	-31.0	-29.5	-30.0	-31.3	-40.9	21.6	-29.5	12	-51.1	9
1996	-39.2	-43.3	-44.5	-44.0	-42.6	-44.9	-46.4	-49.0	-48.8	-38.1	-32.7	-28.7	-27.9	-27.8	-40.1	21.2	-27.8	14	-49.0	8
1997	-36.2	-37.7	-41.0	-40.6	-39.8	-39.0	-40.5	-42.8	-41.7	-36.8	-28.2	-21.8	-23.0	-23.0	-35.6	21.0	-21.8	12	-42.8	8
1998	-27.7	-30.9	-32.4	-32.0	-33.7	-33.9	-32.1	-32.0	-31.2	-24.2	-18.4	-14.3	-15.6	-16.7	-27.3	19.6	-14.3	12	-33.9	6
1999	-21.0	-23.4	-27.0	-26.0	-30.2	-28.7	-26.5	-27.5	-25.2	-19.9	-14.1	-12.3	-12.8	-13.5	-22.4	17.9	-12.3	12	-30.2	5
2000	-18.6	-24.2	-27.9	-25.3	-28.1	-26.1	-21.2	-22.6	-22.2	-16.9	-11.8	-6.4	-8.0	-9.1	-19.8	21.7	-6.4	12	-28.1	5
2001	-16.0	-21.4	-27.0	-25.9	-31.2	-32.0	-30.6	-30.9	-28.4	-22.8	-18.8	-15.1	-16.4	-17.7	-24.0	16.9	-15.1	12	-32.0	5
2002	-23.7	-27.8	-32.3	-31.7	-35.8	-37.4	-36.8	-38.5	-36.5	-30.5	-25.5	-20.6	-21.5	-23.7	-30.2	17.9	-20.6	12	-38.5	8
2003	-29.1	-31.6	-34.7	-33.2	-34.5	-31.6	-28.1	-28.0	-25.8	-22.4	-16.4	-13.0	-14.1	-15.0	-26.3	21.7	-13.0	12	-34.7	3
2004	-22.6	-26.0	-26.7	-26.5	-29.5	-29.4	-24.7	-24.5	-23.4	-18.2	-11.8	-9.2	-10.6	-11.1	-21.6	20.3	-9.2	12	-29.5	5
2005	-19.2	-23.5	-27.4	-29.9	-32.3	-32.8	-31.5	-32.2	-30.8	-21.7	-17.7	-14.0	-15.5	-17.2	-24.8	18.8	-14.0	12	-32.8	6
2006	-24.3	-29.1	-32.5	-35.6	-37.3	-37.6	-37.1	-38.4	-35.4	-28.3	-23.7	-17.6	-17.9	-20.5	-29.9	20.8	-17.6	12	-38.4	8
2007	-26.9	-30.6	-33.0	-35.4	-37.2	-38.2	-35.3	-36.1	-36.3	-29.0	-22.7	-18.2	-18.9	-19.7	-30.2	20.0	-18.2	12	-38.2	5
2008	-26.7	-31.0	-34.5	-37.7	-36.9	-36.1	-31.0	-31.8	-32.6	-26.2	-22.7	-14.3	-13.8	-15.3	-28.7	23.9	-13.8	13	-37.7	4
AVG	-20.4	-23.4	-26.4	-27.8	-29.9	-30.1	-29.0	-29.7	-29.1	-23.4	-18.1	-15.0	-15.5	-16.4						
RNG	39.2	43.3	44.5	44.4	47.4	48.0	48.9	49.6	51.1	40.9	32.7	30.4	30.0	31.4						
SDEV	11.9	13.1	12.8	11.9	11.6	11.9	12.9	13.6	13.6	10.6	5.4	8.4	8.2	8.7						
FMAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
FMIN	-39.2	-43.3	-44.5	-44.4	-47.4	-48.0	-48.9	-49.6	-51.1	-40.9	-32.7	-30.4	-30.0	-31.4						
MXYR	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989						
MNYR	1996	1996	1996	1995	1995	1995	1995	1995	1995	1995	1996	1994	1995	1994						

Figure A4.3.1 Maximum (crosses), mean (squares) and minimum (diamonds) differences between the median (50% exceedance) hydrographs of elevations, Mica Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)

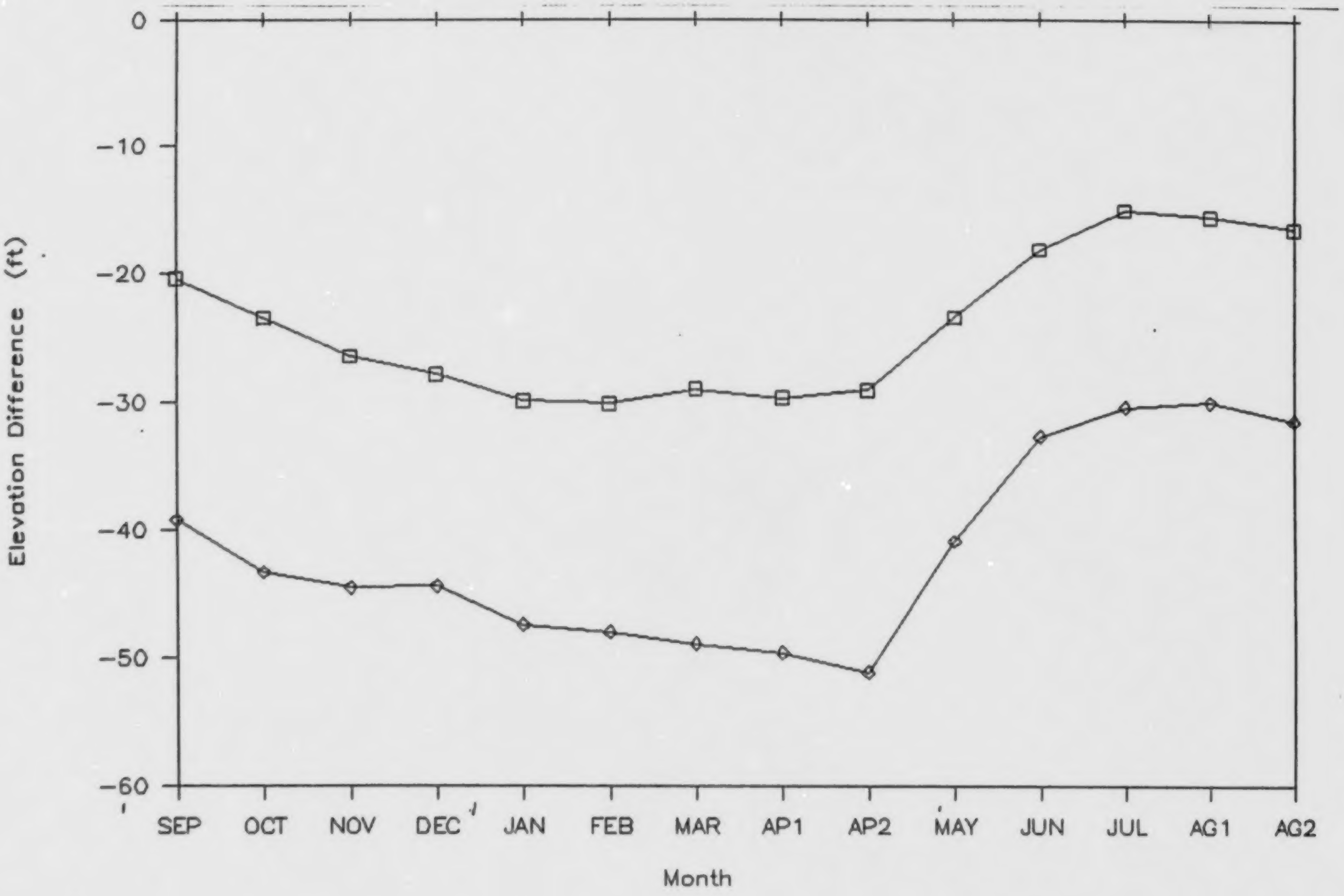


Table A4.3.2 Summary table of differences between median (50% exceedance) outflows, Mica Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	AT	MIN	AT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	6528.0	4135.0	5328.0	0.0	443.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-2.0	1369.4	6530.0	6528.0	2	-2.0	14
1991	4113.0	2649.0	2547.0	5016.0	-2066.0	-6001.0	0.0	0.0	0.0	0.0	0.0	-1003.0	-693.0	-617.0	383.3	11017.0	5016.0	4	-6001.0	6
1992	2062.0	3426.0	3349.0	2893.0	1194.0	-3222.0	0.0	0.0	0.0	0.0	0.0	-3406.0	0.0	-120.0	519.7	6832.0	3426.0	2	-3406.0	12
1993	1808.0	3189.0	5199.0	72.0	0.0	-1718.0	-4087.0	0.0	0.0	0.0	-2761.0	-2756.0	1530.0	1600.0	45.9	9286.0	5199.0	3	-4087.4	7
1994	11139.0	7780.0	5588.0	0.0	0.0	0.0	-1212.0	-2627.0	0.0	0.0	0.0	-4083.0	2201.0	1650.0	1652.0	15222.0	11139.0	1	-4083.0	12
1995	8937.0	4400.0	4547.0	0.0	0.0	0.0	-4702.0	-4610.0	0.0	0.0	-1261.0	-3269.0	1004.0	947.0	610.2	13639.0	8937.0	1	-4702.0	7
1996	10662.0	4184.0	4721.0	0.0	0.0	-107.0	-3103.0	-4217.0	0.0	0.0	-2721.0	-6218.0	1571.0	1418.0	567.0	16880.0	10662.0	1	-6218.0	12
1997	8857.0	4750.0	2363.0	0.0	0.0	-3615.0	-3770.0	-5000.0	0.0	0.0	0.0	-4228.0	2560.0	1600.0	332.1	13857.0	8857.0	1	-5000.0	8
1998	8352.0	3391.0	602.0	0.0	0.0	-1374.0	-2084.0	-4216.0	0.0	0.0	-1279.0	-6876.0	2397.0	2144.0	74.5	15228.0	8352.0	1	-6876.0	12
1999	9167.0	4370.0	700.0	-1171.0	-429.0	-2479.0	-2456.0	0.0	0.0	0.0	0.0	-4192.0	1389.0	242.0	360.5	13359.0	9167.0	1	-4192.0	12
2000	11719.0	5408.0	249.0	0.0	0.0	-3895.0	-3550.0	0.0	0.0	0.0	0.0	-4664.0	3623.0	1273.0	642.9	16383.0	11719.0	1	-4664.0	12
2001	11336.0	7522.0	1222.0	-5000.0	0.0	0.0	-1014.0	0.0	0.0	0.0	0.0	-3236.0	3441.0	1834.0	1122.3	16336.0	11336.0	1	-5000.0	4
2002	10998.0	5976.0	1330.0	-2590.0	0.0	-703.0	-519.0	-110.0	0.0	0.0	0.0	-5917.0	3259.0	1834.0	913.9	16915.0	10998.0	1	-5917.0	12
2003	10365.0	2000.0	281.0	-5000.0	-3369.0	-6938.0	-4975.0	0.0	0.0	0.0	0.0	-3025.0	2807.0	622.0	-745.5	17303.0	10365.0	1	-6938.0	6
2004	12172.0	6368.0	909.0	0.0	0.0	-4482.0	-4489.0	0.0	0.0	0.0	0.0	-4877.0	3819.0	2932.0	740.0	17049.0	12172.0	1	-4877.0	12
2005	12223.0	7037.0	3910.0	0.0	0.0	0.0	-3574.0	0.0	0.0	0.0	0.0	-3861.0	2583.0	1316.0	1474.4	16084.0	12223.0	1	-3861.0	12
2006	12253.0	5394.0	2449.0	0.0	0.0	-1634.0	-4196.0	-1639.0	0.0	0.0	0.0	-5173.0	3223.0	1157.0	872.0	17426.0	12253.0	1	-5173.0	12
2007	10940.0	3840.0	1160.0	0.0	0.0	-3207.0	-2477.0	0.0	0.0	0.0	0.0	-5254.0	3363.0	880.0	593.6	16194.0	10940.0	1	-5254.0	12
2008	11200.0	5783.0	1222.0	0.0	-1490.0	-686.0	-2162.0	-1639.0	0.0	0.0	0.0	-5147.0	3223.0	1351.0	849.0	16347.0	11200.0	1	-5147.0	12
AVG	8415.2	4700.1	2324.6	-27.6	-308.0	-1980.9	-2418.5	-1202.9	0.0	0.0	-401.1	-3859.3	2065.0	1111.1						
RNG	12253.0	7780.0	5588.0	10328.0	4563.0	7381.0	4975.0	5000.0	0.0	0.0	2761.0	6876.0	4512.0	3549.0						
SDEV	4261.5	1963.3	1818.1	2518.5	961.1	2170.2	1739.7	1851.8	0.0	0.0	889.6	1878.0	1393.5	877.7						
FMAX	12253.0	7780.0	5588.0	5328.0	1194.0	443.0	0.0	0.0	0.0	0.0	0.0	0.0	3819.0	2932.0						
FMIN	0.0	0.0	0.0	-5000.0	-3369.0	-6938.0	-4975.0	-5000.0	0.0	0.0	-2761.0	-6876.0	-693.0	-617.0						
MXYR	2006	1994	1994	1990	1992	1990	1989	1989	1989	1989	1989	1989	2004	2004						
MNYR	1989	1989	1989	2001	2003	2003	2003	1997	1989	1989	1993	1998	1991	1991						

Figure A4.3.2 Maximum (crosses), mean (squares) and minimum (diamonds) differences between the median (50% exceedance) hydrographs for outflows, Mica Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)

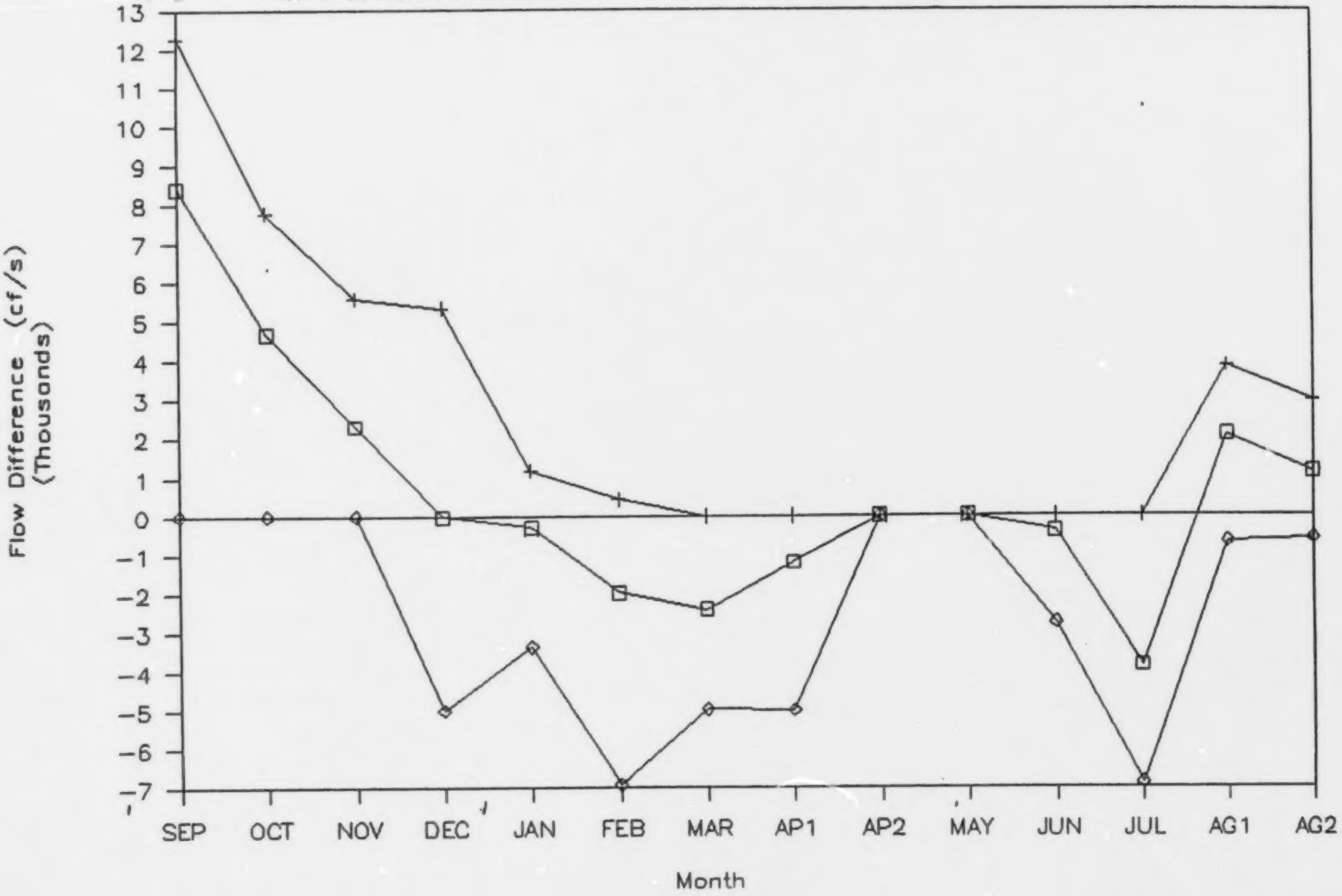


Table A4.3.3 Summary table of differences between median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	0.0	0.0	0.1	0.0	0.0	-3.5	-1.2	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	3.6	0.1	4	-3.5	7
1991	0.0	0.0	0.0	0.1	0.2	0.5	0.4	0.0	0.0	0.3	1.4	0.0	0.0	0.0	0.2	1.4	1.4	11	0.0	1
1992	0.0	0.0	0.0	0.0	0.3	-0.4	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.1	0.7	7	-0.4	6
1993	0.0	0.0	0.1	0.1	0.7	1.0	0.0	0.0	0.7	0.6	0.0	0.0	0.0	0.0	0.2	1.0	1.0	5	0.0	1
1994	0.3	1.4	0.5	0.0	1.1	1.8	0.0	0.0	1.1	0.6	0.5	0.0	0.0	0.0	0.6	1.8	1.8	6	0.0	4
1995	0.5	1.4	1.1	0.0	0.6	1.6	0.1	0.0	2.2	0.1	0.0	0.0	0.0	0.0	0.5	2.2	2.2	9	0.0	4
1996	0.4	1.0	0.5	0.0	1.0	1.1	0.0	0.0	3.0	1.7	0.2	0.0	0.0	0.0	0.6	3.0	3.0	9	0.0	4
1997	0.3	0.4	0.9	0.0	0.1	1.0	0.0	0.0	0.4	1.4	-0.3	0.0	0.0	0.0	0.3	1.7	1.4	10	-0.3	11
1998	0.3	0.9	-0.1	-0.4	0.4	-0.5	0.3	0.0	1.8	0.0	1.7	0.0	0.0	0.0	0.3	2.3	1.8	9	-0.5	5
1999	0.2	0.0	0.3	0.3	0.5	0.3	0.0	0.0	0.1	-0.4	0.2	0.0	0.0	0.0	0.1	0.9	0.5	5	-0.4	10
2000	0.1	0.1	0.5	0.0	0.5	0.7	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.2	1.6	1.6	9	0.0	4
2001	0.3	0.8	1.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.7	0.0	0.0	0.0	0.3	1.7	1.7	9	0.0	4
2002	0.2	0.6	0.1	0.2	0.7	1.5	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.3	1.5	1.5	5	0.0	7
2003	0.2	0.3	1.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.1	1.1	3	0.0	4
2004	0.2	0.1	0.5	0.0	0.8	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.8	0.8	5	0.0	4
2005	0.2	0.2	0.5	0.0	0.2	0.5	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.5	3	0.0	4
2006	0.2	0.1	0.3	0.0	0.6	0.9	0.0	0.8	0.0	2.6	0.5	0.0	0.0	0.0	0.5	2.6	2.6	10	0.0	4
2007	0.2	0.0	0.5	0.0	1.1	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.7	1.7	6	0.0	2
2008	0.1	0.3	0.0	0.0	0.8	0.9	0.5	0.0	0.9	0.0	0.1	0.0	0.0	0.0	0.3	0.9	0.9	6	0.0	3
AVG	0.2	0.4	0.4	0.0	0.5	0.6	-0.1	0.0	0.7	0.3	0.3	0.0	0.0	0.0						
RNG	0.5	1.4	1.2	0.7	1.1	2.3	4.2	2.0	3.0	3.0	2.0	0.0	0.0	0.0						
SDEV	0.1	0.5	0.4	0.1	0.4	0.7	0.8	0.3	0.9	0.7	0.5	0.0	0.0	0.0						
FMAX	0.5	1.4	1.1	0.3	1.1	1.8	0.7	0.8	3.0	2.6	1.7	0.0	0.0	0.0						
FMIN	0.0	0.0	-0.1	-0.4	0.0	-0.5	-3.5	-1.2	0.0	-0.4	-0.3	0.0	0.0	0.0						
MXYR	1995	1994	1995	1999	1994	1994	1992	2006	1996	2006	1998	1989	1989	1989						
MNYR	1989	1989	1998	1998	1989	1998	1990	1990	1989	1999	1997	1989	1989	1989						

Figure A4.3.3 Maximum (crosses), mean (squares) and minimum (diamonds) differences between the median (50% exceedance) hydrographs of elevations, Arrow Lakes Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)

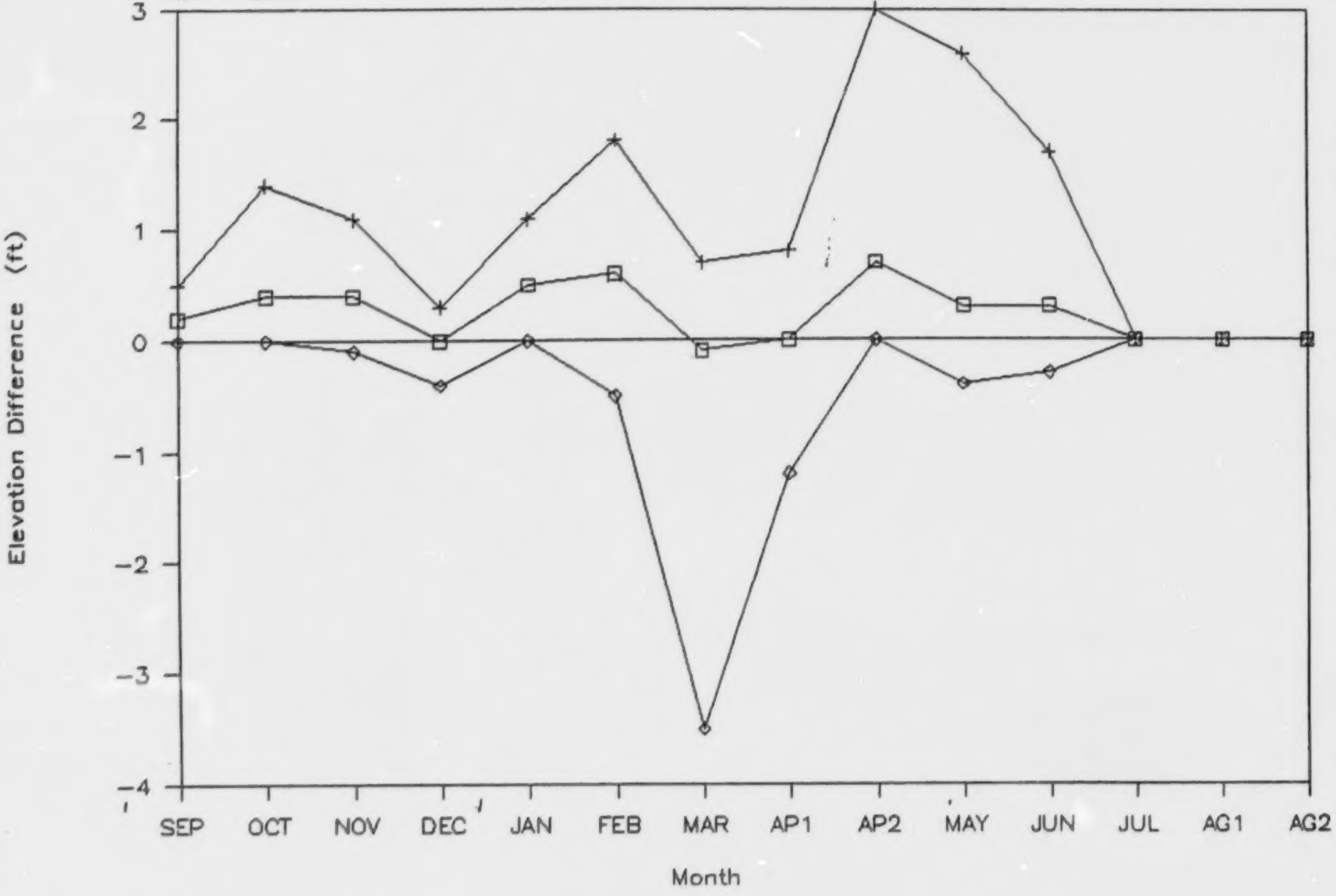
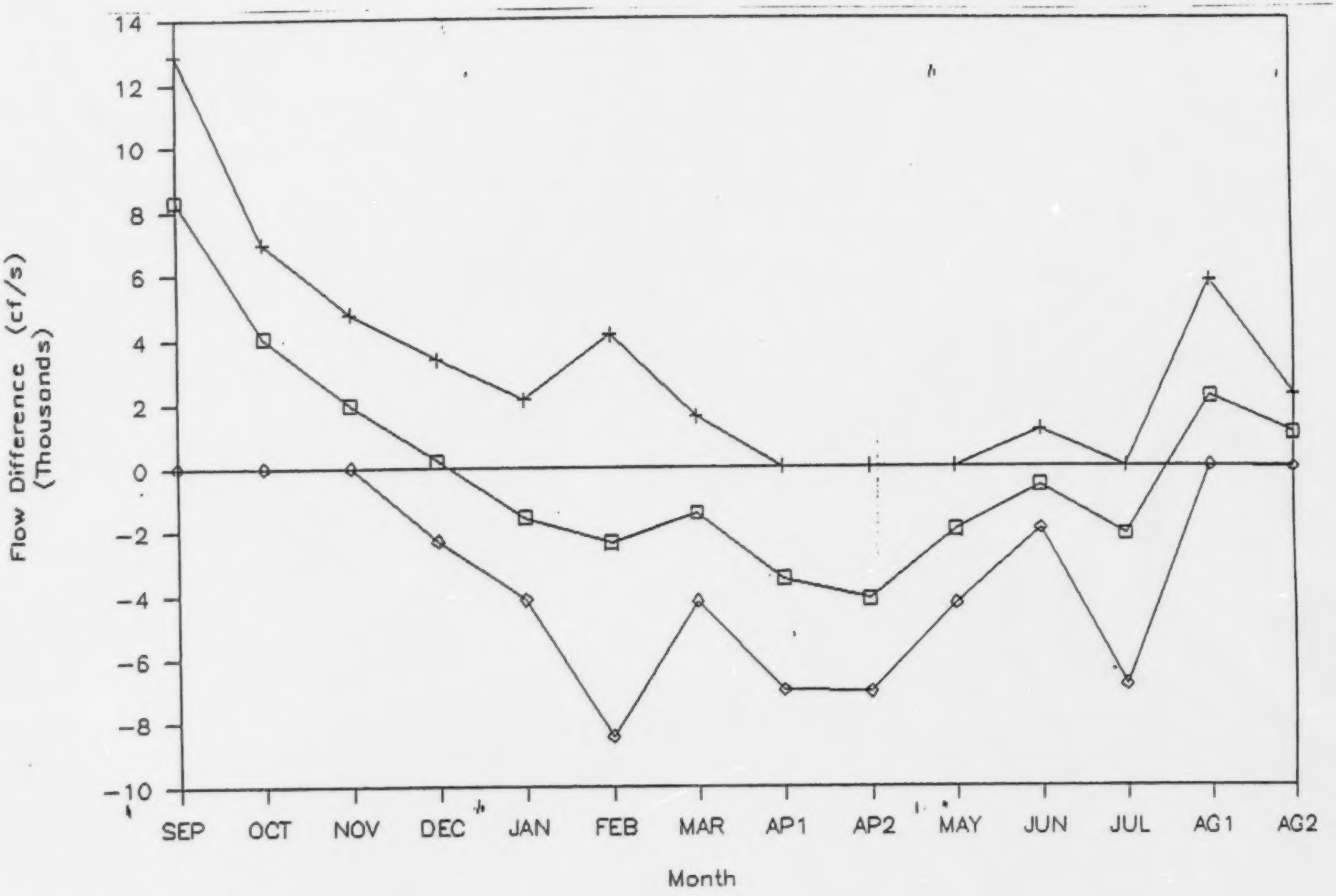


Table A4.3.4 Summary table of differences between median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	5184.0	4785.0	3394.0	-292.0	4117.0	1594.0	-524.0	-1671.0	0.0	-61.0	-4.0	898.0	-50.0	1503.6	6855.0	5184.0	2	-1671.0	9
1991	2283.0	2853.0	2536.0	1467.0	-398.0	1561.0	-119.0	-1016.0	-1847.0	-61.0	-444.0	-2426.0	0.0	421.0	502.6	5279.0	2853.0	2	-2426.0	12
1992	1514.0	2392.0	2222.0	2328.0	2153.0	3208.0	-740.0	-3315.0	-1817.0	-845.0	-294.0	-625.0	0.0	349.0	743.5	6523.0	3208.0	6	-3315.0	8
1993	952.0	2125.0	3931.0	2737.0	1909.0	2060.0	696.0	-1749.0	-2645.0	-722.0	-1165.0	-1869.0	4133.0	1771.0	950.8	6778.0	4133.0	13	-2645.0	9
1994	10240.0	5267.0	3792.0	2305.0	-1039.0	2778.0	292.0	-3320.0	-5111.0	-2777.0	506.0	-718.0	3292.0	1319.0	1561.3	15351.0	10240.0	1	-5111.0	9
1995	8767.0	3243.0	2056.0	1122.0	-2759.0	-984.0	-1996.0	-4613.0	-7020.0	-3096.0	-1935.0	-2117.0	2380.0	1083.0	-148.7	15787.0	8767.0	1	-7020.0	9
1996	9720.0	3504.0	1950.0	843.0	-941.0	-8271.0	-282.0	-5079.0	-5991.0	-4273.0	-525.0	-6807.0	3471.0	1771.0	-666.3	17991.0	9720.0	1	-8271.0	6
1997	9694.0	2582.0	839.0	238.0	-2977.0	-8404.0	839.0	-3763.0	-4449.0	-2747.0	-1751.0	-2025.0	479.0	390.0	-615.3	18098.0	9694.0	1	-8404.0	6
1998	9147.0	2593.0	1094.0	-741.0	-1783.0	-6023.0	-3146.0	-3724.0	-5461.0	-3705.0	-1320.0	-1886.0	2226.0	1375.0	-713.5	15170.0	9147.0	1	-6023.0	6
1999	8345.0	3992.0	1025.0	-636.0	-2422.0	-6029.0	-3996.0	-3736.0	-5019.0	-2260.0	1147.0	-2338.0	286.0	736.0	-586.5	14374.0	8345.0	1	-6029.0	6
2000	12174.0	5311.0	521.0	-1022.0	-3588.0	-6363.0	-1596.0	-3767.0	-2213.0	-2245.0	377.0	-4633.0	2438.0	440.0	-284.6	18537.0	12174.0	1	-6363.0	6
2001	12621.0	6629.0	1501.0	-1915.0	-1392.0	-2800.0	-2320.0	-5112.0	-4374.0	-874.0	-778.0	-958.0	5760.0	2267.0	748.7	17733.0	12621.0	1	-5112.0	8
2002	10341.0	4886.0	1009.0	-1114.0	-735.0	2308.0	-829.0	-3215.0	-5738.0	-1018.0	-603.0	-1956.0	4296.0	2032.0	981.4	16079.0	10341.0	1	-5738.0	9
2003	10244.0	2556.0	867.0	-2295.0	-4118.0	-5342.0	-3456.0	-3737.0	-4979.0	-3245.0	-1320.0	-83.0	2021.0	219.0	-785.8	15586.0	10244.0	1	-5342.0	6
2004	12336.0	5790.0	1797.0	-1782.0	-2781.0	-4490.0	-2817.0	-4897.0	-4374.0	-1273.0	-972.0	-4594.0	4624.0	1601.0	-26.4	17233.0	12336.0	1	-4897.0	8
2005	11877.0	7007.0	3014.0	317.0	-2746.0	-4475.0	-4193.0	-3818.6	-5588.0	-2937.0	468.0	-216.0	4341.0	1590.0	531.5	17465.0	11877.0	1	-5588.0	9
2006	12884.0	5327.0	2534.0	-789.0	-457.0	-5605.0	-2566.0	-6948.0	-5382.0	-3247.0	-1665.0	-80.0	1934.0	1273.0	147.9	19832.0	12884.0	1	-6948.0	8
2007	11193.0	4376.0	1852.0	492.0	-3995.0	-1584.0	-1212.0	-5377.0	-4437.0	-2463.0	-323.0	-4794.0	898.0	1633.0	-8.3	16570.0	11193.0	1	-5377.0	8
2008	12110.0	5762.0	1679.0	-132.0	-2919.0	-2572.0	-2853.0	-1921.0	-4374.0	-1759.0	-1025.0	-4363.0	420.0	250.0	93.0	16484.0	12110.0	1	-4374.0	9
AVG	8322.1	4060.9	1990.2	200.9	-1564.0	-2345.9	-1435.0	-3481.6	-4124.5	-1977.3	-584.2	-2124.6	2194.9	1023.5						
RNG	12884.0	7007.0	4785.0	5689.0	6271.0	12521.0	5707.0	6948.0	7020.0	4273.0	3082.0	6807.0	5760.0	2317.0						
SDEV	4572.7	1775.4	1200.7	1649.9	1767.5	4021.0	1707.4	1733.2	1810.2	1303.8	832.4	1964.7	1805.9	728.1						
FMAX	12884.0	7007.0	4785.0	3394.0	2153.0	4117.0	1594.0	0.0	0.0	0.0	1147.0	0.0	5760.0	2267.0						
FMIN	0.0	0.0	0.0	-2295.0	-4118.0	-8404.0	-4193.0	-6948.0	-7020.0	-4273.0	-1935.0	-6807.0	0.0	-50.0						
MXYR	2006	2005	1990	1990	1992	1990	1990	1989	1989	1989	1999	1989	2001	2001						
MNYR	1989	1989	1989	2003	2003	1997	2005	2006	1995	1996	1995	1996	1989	1990						

Figure A4.3.4 Maximum (crosses), mean (squares) and minimum (diamonds) differences between the median (50% exceedance) hydrographs for outflows, Arrow Lakes Reservoir, Regime 1 (Medium Load) - Base Case (Medium Load)



APPENDIX 4.4

Regime 2 (Medium Load)

Table A4.4.1 Summary table of median (50% exceedance) elevations, Mica Reservoir, Regime 2 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN
1989	2460.1	2460.9	2456.7	2436.7	2423.0	2412.9	2401.9	2397.8	2397.1	2409.9	2442.1	2470.8	2472.5	2473.6	2437.1	76.5	2473.6	14	2397.1
1990	2470.7	2465.9	2458.2	2441.2	2426.6	2417.4	2405.2	2401.3	2401.1	2417.3	2444.8	2469.8	2471.7	2472.3	2440.9	71.2	2472.3	14	2401.1
1991	2469.3	2464.4	2457.2	2440.7	2424.7	2414.0	2402.1	2398.1	2398.0	2411.7	2442.6	2469.3	2471.8	2471.1	2430.8	73.8	2471.8	13	2398.0
1992	2468.1	2462.8	2455.6	2441.6	2427.9	2417.4	2405.3	2399.3	2398.4	2413.6	2441.1	2465.2	2465.8	2467.9	2438.7	69.7	2468.1	1	2398.4
1993	2464.0	2460.0	2455.2	2439.8	2423.9	2408.9	2393.7	2386.5	2387.5	2402.9	2435.0	2458.4	2461.0	2462.2	2432.5	77.5	2464.0	1	2386.5
1994	2458.6	2454.6	2447.6	2433.8	2419.9	2407.2	2390.2	2381.4	2381.4	2401.8	2429.0	2452.2	2455.7	2455.3	2427.6	77.2	2458.6	1	2381.4
1995	2453.1	2449.1	2444.8	2432.7	2416.7	2404.2	2391.4	2382.1	2382.1	2400.3	2430.2	2453.8	2456.7	2456.5	2426.3	74.6	2456.7	13	2382.1
1996	2453.6	2451.0	2446.1	2433.4	2419.1	2406.2	2391.4	2382.7	2383.2	2400.9	2430.3	2453.4	2456.7	2457.5	2427.1	74.8	2457.5	14	2382.7
1997	2453.3	2450.6	2446.3	2434.2	2422.1	2409.8	2393.4	2385.8	2384.0	2402.2	2432.3	2456.9	2459.8	2460.4	2428.8	76.4	2460.4	14	2384.0
1998	2457.0	2454.1	2449.2	2435.3	2421.2	2409.2	2395.9	2387.9	2388.3	2403.2	2434.4	2460.3	2461.8	2461.9	2430.8	74.0	2461.9	14	2387.9
1999	2459.6	2456.2	2451.5	2437.8	2423.2	2411.7	2397.5	2390.4	2390.0	2405.0	2437.0	2457.8	2462.0	2462.2	2432.5	72.2	2462.2	14	2390.0
2000	2459.4	2454.9	2450.7	2437.6	2424.3	2412.9	2400.5	2392.9	2392.9	2408.7	2441.4	2464.5	2467.9	2469.0	2434.7	76.1	2469.0	14	2392.9
2001	2464.8	2458.9	2451.8	2437.6	2423.0	2409.8	2395.4	2387.8	2388.4	2401.2	2433.7	2457.3	2459.8	2459.9	2431.8	77.0	2464.8	1	2387.8
2002	2456.1	2451.8	2445.3	2433.2	2417.9	2403.6	2388.1	2380.4	2380.2	2400.1	2430.5	2451.6	2454.0	2454.2	2426.1	75.9	2456.1	1	2380.2
2003	2450.6	2448.6	2444.8	2433.1	2418.1	2406.3	2391.3	2383.4	2382.6	2404.0	2433.5	2456.4	2458.6	2458.8	2427.4	76.2	2458.8	14	2382.6
2004	2456.0	2453.6	2448.9	2435.9	2422.4	2409.9	2396.4	2389.3	2389.4	2408.8	2440.4	2460.7	2462.7	2463.3	2432.1	74.0	2463.3	14	2389.3
2005	2458.9	2454.1	2450.5	2436.1	2421.7	2408.8	2394.3	2386.5	2386.0	2404.9	2433.6	2458.1	2459.0	2459.0	2430.5	73.0	2459.0	13	2386.0
2006	2454.0	2450.1	2444.9	2433.7	2418.1	2404.5	2389.4	2382.3	2381.4	2401.3	2431.1	2451.7	2455.1	2455.4	2426.3	74.0	2455.4	14	2381.4
2007	2451.5	2448.6	2444.8	2433.4	2417.6	2405.2	2389.5	2381.5	2382.5	2400.1	2430.6	2453.9	2457.4	2457.7	2426.2	76.2	2457.7	14	2381.5
2008	2452.7	2448.6	2444.8	2433.7	2418.3	2406.7	2392.0	2383.6	2384.3	2401.9	2432.2	2457.0	2459.4	2459.7	2427.6	76.1	2459.7	14	2383.6
AVG	2458.6	2454.9	2449.7	2436.1	2421.5	2409.3	2395.2	2388.1	2387.9	2405.0	2435.3	2459.0	2461.5	2461.9					
RNG	20.1	17.3	13.4	8.9	11.2	13.8	17.2	20.9	20.9	17.2	15.8	19.2	18.5	19.4					
SDEV	6.0	5.5	4.7	2.9	3.2	4.1	5.3	6.6	6.5	5.0	5.0	6.0	5.7	5.9					
FMAX	2470.7	2465.9	2458.2	2441.6	2427.9	2417.4	2405.3	2401.3	2401.1	2417.3	2444.8	2470.8	2472.5	2473.6					
FMIN	2450.6	2448.6	2444.8	2432.7	2416.7	2403.6	2388.1	2380.4	2380.2	2400.1	2429.0	2451.6	2454.0	2454.2					
MXYR	1990	1990	1990	1992	1992	1990	1992	1990	1990	1990	1990	1989	1989	1989					
MNYR	2003	2003	1995	1995	1995	2002	2002	2002	2002	2002	1994	2002	2002	2002					

Figure A4.4.1 Maximum, mean and minimum median monthly hydrograph of elevations, Mica Reservoir, Regime 2 (Medium Load)

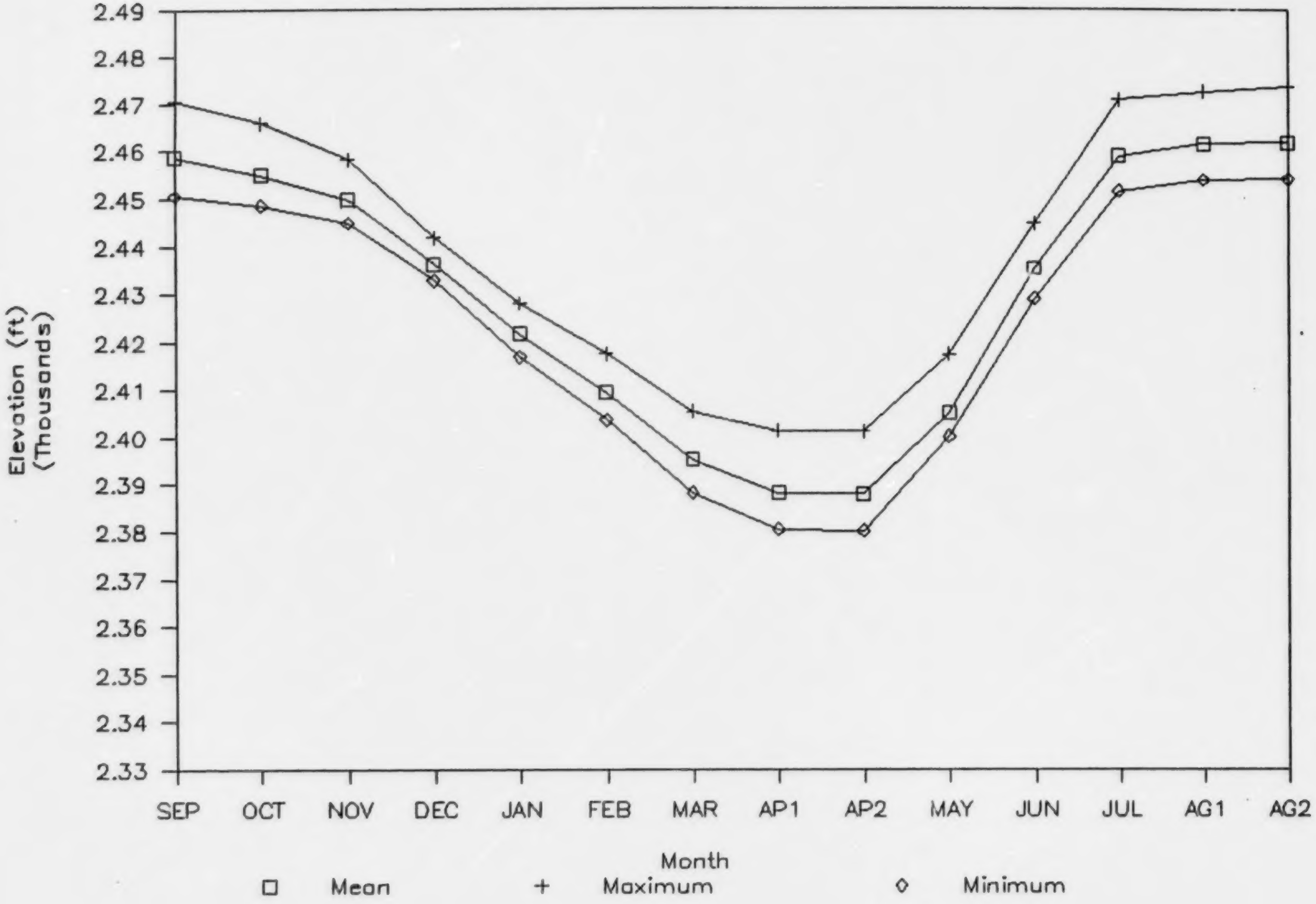


Table A4.4.2 Summary table of median (50% exceedance) outflows, Mica Reservoir, Regime 2 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	13561.0	11650.0	17476.0	33583.0	22311.0	20084.0	17000.0	15000.0	10000.0	10000.0	10000.0	21184.0	34000.0	32519.0	18550.7	24000.0	34000.0	13	10000.0	9
1990	23309.0	19204.0	19052.0	32279.0	26000.0	22200.0	17000.0	15000.0	10000.0	10000.0	10000.0	27264.0	36851.0	34535.0	21208.4	26851.0	36851.0	13	10000.0	9
1991	26432.0	17743.0	18541.0	30720.0	25500.0	22479.0	20000.0	15000.0	10000.0	10000.0	10000.0	25847.0	34850.0	37687.0	21335.9	27687.0	37687.0	14	10000.0	9
1992	26660.0	18233.0	18332.0	25065.0	22506.0	17657.0	18000.0	18000.0	18000.0	10000.0	10000.0	26378.0	40000.0	34715.0	20682.4	30000.0	40000.0	13	10000.0	10
1993	27180.0	18340.0	15500.0	27454.0	27000.0	24417.0	21461.0	27000.0	10000.0	10000.0	10000.0	24390.0	33500.0	33217.0	21466.7	23500.0	33500.0	13	10000.0	9
1994	26438.0	18340.0	15528.0	27625.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	24252.0	34000.0	33149.0	21604.8	24000.0	34000.0	13	10000.0	9
1995	25828.0	17266.0	15358.0	27000.0	27000.0	25000.0	20541.0	25361.0	10000.0	10000.0	10000.0	23065.0	33500.0	32037.0	20958.9	23500.0	33500.0	13	10000.0	9
1996	26406.0	17973.0	16026.0	27000.0	25502.0	23667.0	21484.0	27000.0	10000.0	10000.0	10000.0	24852.0	33501.0	33217.0	21230.8	23501.0	33501.0	13	10000.0	9
1997	26368.0	17777.0	15300.0	26954.0	24876.0	24181.0	22305.0	27000.0	10000.0	10000.0	10000.0	23959.0	34470.0	33149.0	21169.1	24470.0	34470.0	13	10000.0	9
1998	26446.0	16962.0	14198.0	27000.0	26599.0	24049.0	22979.0	27000.0	10000.0	10000.0	10000.0	25661.0	34773.0	33149.0	21362.9	24773.0	34773.0	13	10000.0	9
1999	26851.0	18011.0	14198.0	27000.0	27000.0	24836.0	23000.0	27000.0	10000.0	10000.0	10000.0	23975.0	33810.0	33148.0	21404.2	23810.0	33810.0	13	10000.0	9
2000	26271.0	17097.0	14277.0	22276.0	25392.0	23784.0	22016.0	27000.0	10000.0	10000.0	10000.0	27903.0	35532.0	33796.0	21015.0	25532.0	35532.0	13	10000.0	9
2001	27403.0	18340.0	15300.0	23856.0	26629.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	25686.0	34706.0	33717.0	21493.8	24706.0	34706.0	13	10000.0	9
2002	26872.0	18340.0	15214.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	24528.0	34743.0	33717.0	21640.3	24743.0	34743.0	13	10000.0	9
2003	26028.0	15760.0	13215.0	24120.0	24706.0	23483.0	23000.0	27000.0	10000.0	10000.0	10000.0	24231.0	34000.0	32957.0	20543.5	24000.0	34000.0	13	10000.0	9
2004	26438.0	17032.0	13989.0	23301.0	25505.0	23046.0	21992.0	27000.0	10000.0	10000.0	10000.0	28500.0	35239.0	35167.0	21125.5	25239.0	35239.0	13	10000.0	9
2005	26938.0	18340.0	14198.0	26701.0	26517.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	26459.0	35413.0	34005.0	21575.0	25413.0	35413.0	13	10000.0	9
2006	27432.0	17939.0	14069.0	24792.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	24202.0	35413.0	33717.0	21162.4	25413.0	35413.0	13	10000.0	9
2007	26438.0	16750.0	14198.0	24774.0	26522.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	25800.0	35287.0	33194.0	21048.7	25287.0	35287.0	13	10000.0	9
2008	26438.0	16869.0	14198.0	22000.0	26539.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	25800.0	35287.0	33194.0	21048.7	25287.0	35287.0	13	10000.0	9
AVG	25786.8	17398.3	15408.3	26525.0	25855.2	23694.2	21588.9	24668.1	10400.0	10000.0	10000.0	25137.6	34903.6	33725.4						
RNG	13871.0	7554.0	5837.0	11583.0	4689.0	7343.0	6000.0	12000.0	8000.0	0.0	0.0	7316.0	6500.0	5650.0						
SDEV	2998.5	1564.6	1679.7	3025.9	1396.1	1912.5	2043.7	4627.9	1788.9	0.0	0.0	1696.9	1467.9	1181.4						
FMAX	27432.0	19204.0	19052.0	33583.0	27000.0	25000.0	23000.0	27000.0	18000.0	10000.0	10000.0	28500.0	40000.0	37687.0						
FMIN	13561.0	11650.0	13215.0	22000.0	22311.0	17657.0	17000.0	15000.0	10000.0	10000.0	10000.0	21184.0	33500.0	32037.0						
MXYR	2006	1990	1990	1989	1993	1994	1994	1993	1992	1989	1989	2004	1992	1991						
MNYR	1989	1989	2003	2008	1989	1992	1989	1989	1989	1989	1989	1989	1993	1995						

Figure A4.4.2 Maximum, mean and minimum median monthly hydrograph of outflows, Mica Reservoir, Regime 2 (Medium Load)

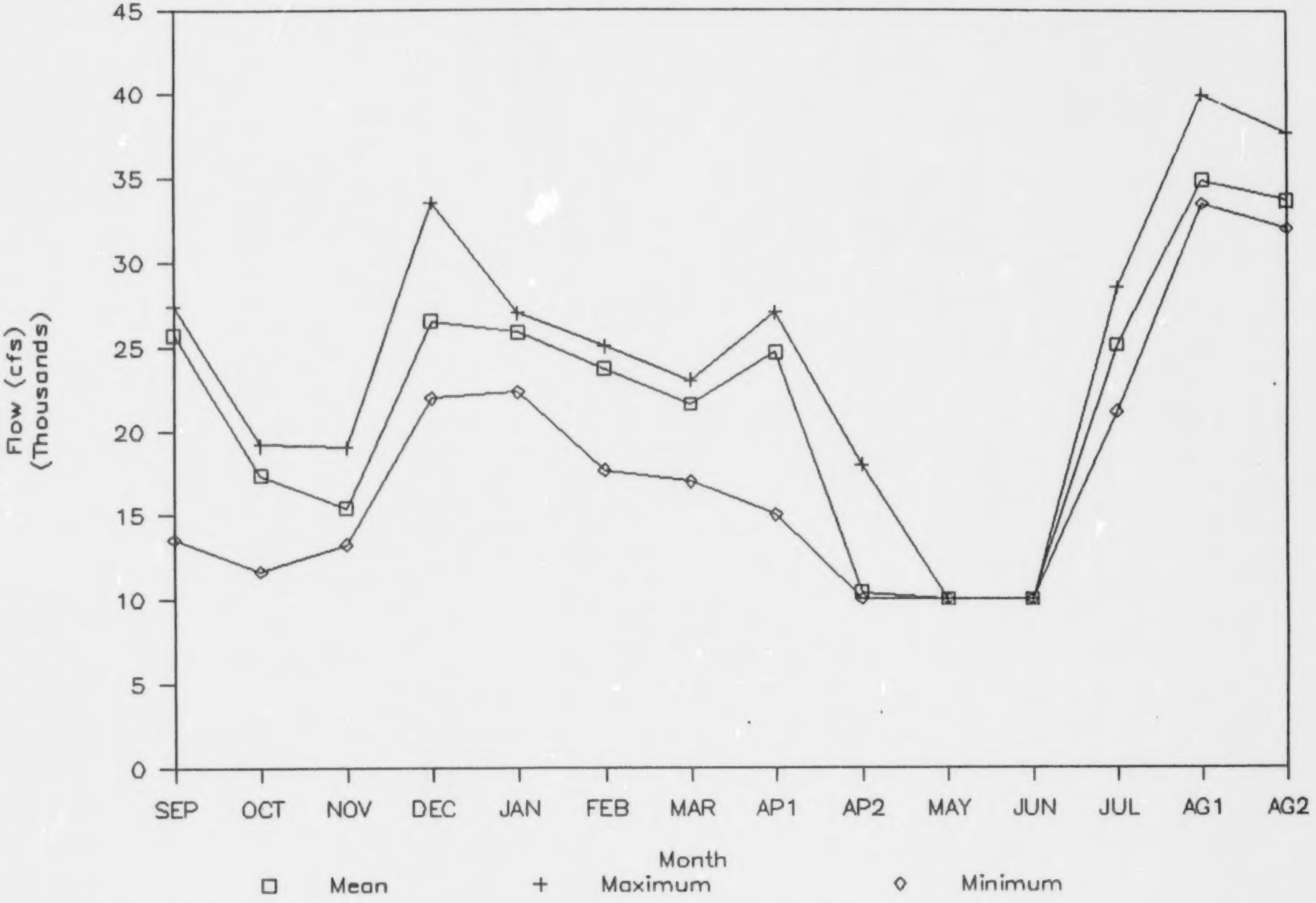


Table A4.4.3 Summary table of median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 2 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	1443.1	1438.8	1437.5	1433.0	1409.1	1397.8	1398.4	1399.9	1399.9	1415.3	1437.5	1444.0	1444.0	1444.0	1424.9	46.2	1444.0	12	1397.8	6
1990	1444.0	1441.9	1438.3	1431.5	1406.4	1396.1	1397.9	1399.9	1399.9	1414.6	1435.3	1444.0	1444.0	1444.0	1424.5	47.9	1444.0	1	1396.1	6
1991	1444.0	1441.9	1438.7	1432.8	1407.8	1399.8	1399.1	1399.9	1399.9	1415.2	1436.6	1444.0	1444.0	1444.0	1425.3	44.9	1444.0	1	1399.1	7
1992	1443.9	1441.9	1439.4	1431.8	1405.5	1396.9	1395.9	1399.5	1399.9	1414.6	1437.0	1444.0	1444.0	1444.0	1424.6	48.1	1444.0	12	1395.9	7
1993	1443.8	1441.4	1438.5	1434.1	1406.9	1398.7	1398.9	1399.9	1401.4	1415.2	1435.6	1444.0	1444.0	1444.0	1425.1	45.3	1444.0	12	1398.7	6
1994	1443.8	1441.1	1439.3	1435.2	1410.0	1400.1	1399.9	1399.9	1402.0	1415.2	1436.6	1444.0	1444.0	1444.0	1425.8	44.1	1444.0	12	1399.9	7
1995	1443.7	1441.0	1439.2	1435.1	1409.8	1400.5	1398.9	1399.9	1402.1	1414.6	1435.6	1444.0	1444.0	1444.0	1425.6	45.1	1444.0	12	1398.9	7
1996	1443.7	1440.9	1439.5	1436.1	1411.8	1402.9	1399.9	1399.9	1401.1	1414.1	1436.1	1444.0	1444.0	1444.0	1426.1	44.1	1444.0	12	1399.9	7
1997	1443.8	1441.5	1439.7	1435.6	1410.6	1401.8	1399.9	1399.9	1401.7	1413.1	1435.3	1444.0	1444.0	1444.0	1425.8	44.1	1444.0	12	1399.9	7
1998	1443.8	1441.2	1438.6	1434.0	1408.9	1399.0	1399.9	1399.9	1400.3	1415.2	1436.1	1444.0	1444.0	1444.0	1425.4	45.0	1444.0	12	1399.0	6
1999	1443.8	1441.8	1439.3	1434.9	1409.7	1402.0	1399.9	1399.9	1402.8	1415.1	1437.3	1444.0	1444.0	1444.0	1426.1	44.1	1444.0	12	1399.9	7
2000	1443.9	1441.9	1441.0	1436.2	1412.2	1404.1	1399.9	1399.9	1403.4	1415.2	1435.3	1444.0	1444.0	1444.0	1426.6	44.1	1444.0	12	1399.9	7
2001	1443.8	1441.6	1440.1	1436.2	1411.4	1402.7	1399.9	1399.9	1401.8	1415.2	1436.1	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	12	1399.9	7
2002	1443.9	1441.5	1439.1	1434.0	1410.6	1400.1	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1425.9	44.1	1444.0	12	1399.9	7
2003	1443.9	1441.5	1440.3	1436.1	1411.8	1403.4	1399.9	1399.9	1403.4	1415.2	1437.5	1444.0	1444.0	1444.0	1426.6	44.1	1444.0	12	1399.9	7
2004	1443.9	1441.9	1440.5	1436.2	1412.9	1403.8	1399.9	1399.9	1402.1	1415.2	1437.3	1444.0	1444.0	1444.0	1426.7	44.1	1444.0	12	1399.9	7
2005	1443.9	1441.7	1440.6	1436.2	1412.3	1404.5	1399.9	1399.9	1403.3	1415.2	1437.5	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	12	1399.9	7
2006	1443.9	1441.9	1441.0	1436.2	1413.3	1406.4	1399.9	1399.9	1403.9	1415.2	1435.3	1444.0	1444.0	1444.0	1426.9	44.1	1444.0	12	1399.9	7
2007	1443.9	1441.7	1440.9	1436.2	1410.6	1401.9	1399.9	1399.9	1403.4	1415.2	1436.1	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	12	1399.9	7
2008	1443.9	1441.7	1441.9	1436.2	1412.9	1401.7	1399.4	1399.9	1402.1	1414.9	1435.7	1444.0	1444.0	1444.0	1426.4	44.6	1444.0	12	1399.4	7
AVG	1443.8	1441.4	1439.7	1434.9	1410.2	1401.2	1399.4	1399.9	1401.9	1414.9	1436.4	1444.0	1444.0	1444.0						
RNG	0.9	3.1	4.4	4.7	7.8	10.3	4.0	0.4	4.0	2.2	2.2	0.0	0.0	0.0						
SDEV	0.2	0.7	1.1	1.6	2.2	2.7	1.0	0.1	1.4	0.5	0.8	0.0	0.0	0.0						
FMAX	1444.0	1441.9	1441.9	1436.2	1413.3	1406.4	1399.9	1399.9	1403.9	1415.3	1437.5	1444.0	1444.0	1444.0						
FMIN	1443.1	1438.8	1437.5	1431.5	1405.5	1396.1	1395.9	1399.5	1399.9	1413.1	1435.3	1444.0	1444.0	1444.0						
MXYR	1990	1990	2008	2000	2006	2006	1994	1989	2006	1989	1989	1989	1989	1989						
MNYR	1989	1989	1989	1990	1992	1990	1992	1992	1989	1997	1990	1989	1989	1989						

Figure A4.4.3 Maximum, mean and minimum median monthly hydrograph of elevations, Arrow Lakes Reservoir, Regime 2 (Medium Load)

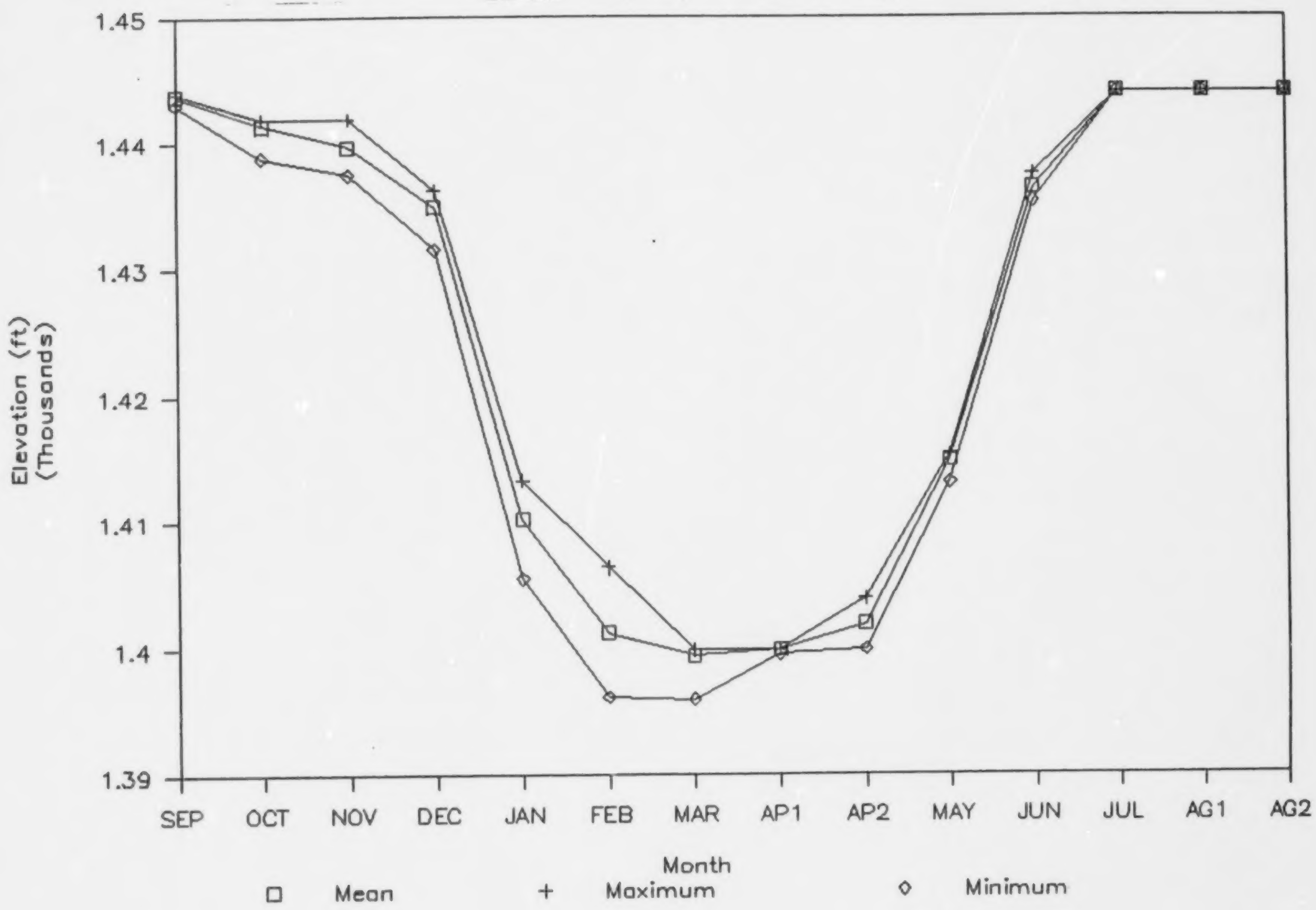
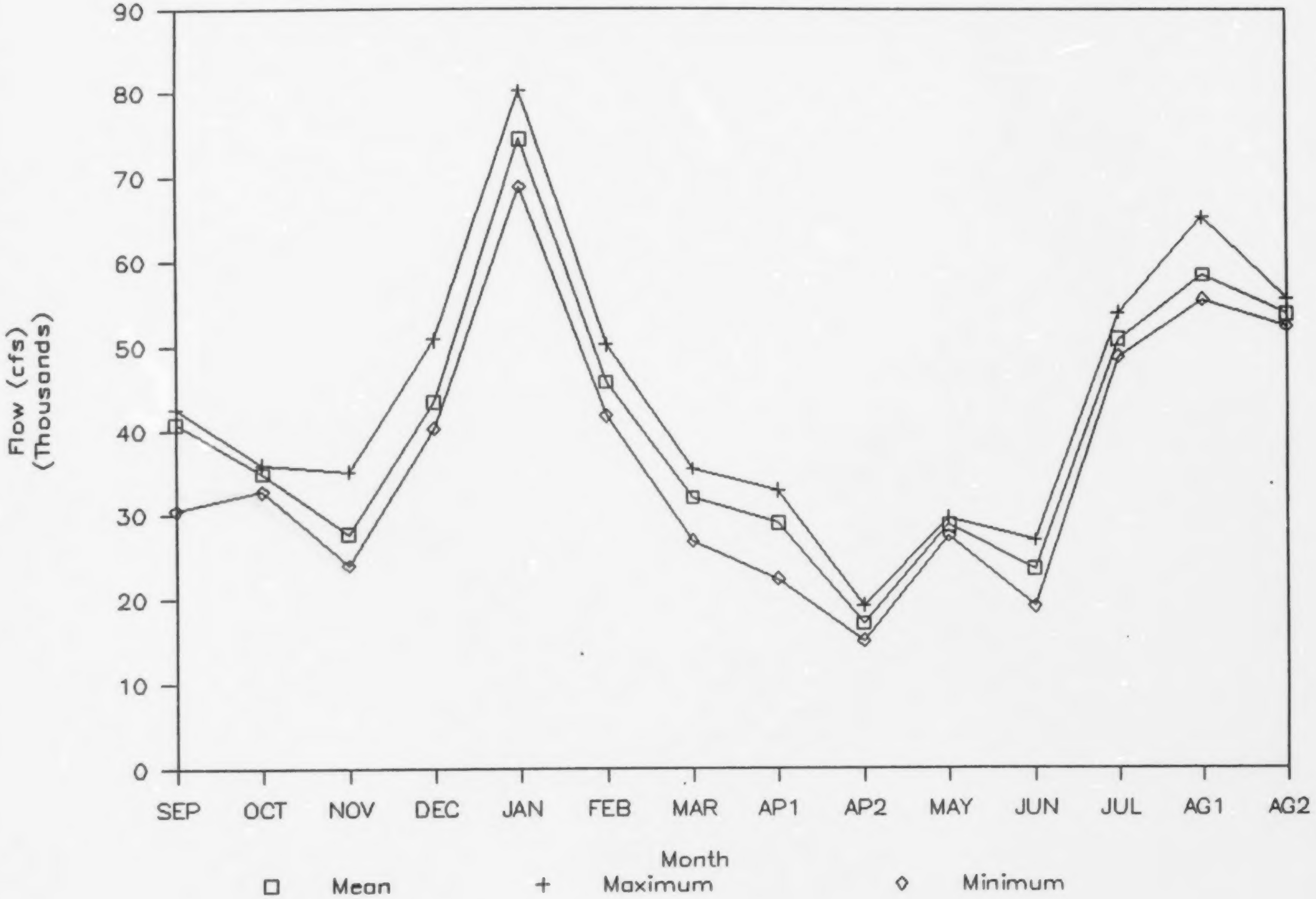


Table A4.4.4 Summary table of median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 2 (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	30467.0	32744.0	32253.0	47405.0	71966.0	41785.0	26835.0	22886.0	16037.0	28025.0	21046.0	50764.0	57955.0	53121.0	38197.5	55929.0	71966.0	5	16037.0	9
1990	38825.0	35987.0	35096.0	50856.0	77025.0	45924.0	28340.0	22337.0	16693.0	28903.0	25986.0	50350.0	61004.0	53270.0	41195.3	60332.0	77025.0	5	16693.0	9
1991	40901.0	35026.0	31749.0	47572.0	73416.0	44554.0	30782.0	22690.0	17347.0	28834.0	24583.0	53890.0	60293.0	55492.0	40768.2	56069.0	73416.0	5	17347.0	9
1992	41852.0	35385.0	30835.0	46765.0	71595.0	43368.0	30077.0	24470.0	19192.0	28858.0	22644.0	50692.0	65172.0	54162.0	40297.4	52403.0	71595.0	5	19192.0	9
1993	41916.0	35054.0	29722.0	44553.0	80174.0	45536.0	32093.0	29008.0	17347.0	28744.0	24423.0	49341.0	56176.0	54722.0	40848.5	62827.0	80174.0	5	17347.0	9
1994	42052.0	35827.0	28352.0	43805.0	74854.0	47671.0	32551.0	30108.0	15369.0	28216.0	21545.0	50731.0	56213.0	52872.0	40240.4	59485.0	74854.0	5	15369.0	9
1995	41585.0	34181.0	26973.0	43182.0	78672.0	45150.0	30475.0	29276.0	15543.0	28497.0	21241.0	48717.0	56746.0	53103.0	39667.3	63129.0	78672.0	5	15543.0	9
1996	41033.0	35259.0	27202.0	43638.0	71495.0	45357.0	32771.0	32601.0	17846.0	28903.0	21295.0	51228.0	56093.0	54404.0	39887.8	53649.0	71495.0	5	17846.0	9
1997	41533.0	35156.0	27379.0	42613.0	75040.0	44333.0	32146.0	29276.0	17572.0	29234.0	19097.0	49164.0	59004.0	53928.0	39632.1	57468.0	75040.0	5	17572.0	9
1998	42184.0	35425.0	27580.0	42475.0	76899.0	45938.0	30373.0	30116.0	17347.0	28903.0	23834.0	49662.0	59673.0	54572.0	40343.9	59552.0	76899.0	5	17347.0	9
1999	40827.0	35205.0	27391.0	42120.0	73926.0	44262.0	32387.0	29486.0	16989.0	28903.0	22529.0	49164.0	56819.0	53662.0	39599.3	56937.0	73926.0	5	16989.0	9
2000	41030.0	35038.0	25231.0	41035.0	72987.0	46416.0	34718.0	30937.0	17846.0	28903.0	26040.0	52176.0	59864.0	55394.0	40466.2	55141.0	72987.0	5	17846.0	9
2001	42089.0	35426.0	27089.0	41395.0	78054.0	47027.0	32329.0	30418.0	17877.0	28684.0	23811.0	49777.0	56842.0	53675.0	40423.9	60177.0	78054.0	5	17877.0	9
2002	42616.0	35864.0	27912.0	42003.0	75367.0	45746.0	30783.0	29486.0	16743.0	29571.0	23518.0	51388.0	56841.0	53603.0	40325.4	58624.0	75367.0	5	16743.0	9
2003	40099.0	33206.0	24040.0	41160.0	73432.0	44907.0	33017.0	29486.0	15117.0	29520.0	22529.0	51315.0	58167.0	52323.0	39231.0	58315.0	73432.0	5	15117.0	9
2004	41095.0	33357.0	24452.0	40305.0	72967.0	46916.0	35371.0	32870.0	16774.0	28903.0	25942.0	51388.0	58220.0	54808.0	40169.3	56193.0	72967.0	5	16774.0	9
2005	42208.0	35500.0	25028.0	42255.0	73252.0	45389.0	32720.0	32870.0	18944.0	27446.0	25198.0	51513.0	55457.0	53260.0	40064.5	54308.0	73252.0	5	18944.0	9
2006	41021.0	35072.0	24374.0	42035.0	68862.0	45100.0	33915.0	32698.0	17846.0	28903.0	26926.0	50904.0	57149.0	52870.0	39782.8	51016.0	68862.0	5	17846.0	9
2007	41998.0	34916.0	25668.0	42255.0	77465.0	50171.0	32518.0	28933.0	16459.0	28531.0	24245.0	51388.0	58129.0	53260.0	40628.8	61006.0	77465.0	5	16459.0	9
2008	41426.0	34386.0	24591.0	41828.0	73455.0	49415.0	34753.0	29558.0	17347.0	28419.0	23768.0	52366.0	60493.0	53365.0	40399.0	56108.0	73455.0	5	17347.0	9
AVG	40837.9	34900.7	27645.8	43506.8	74545.1	45748.3	31947.7	28975.5	17111.8	28745.0	23510.0	50795.9	58355.5	53793.3						
RNG	12149.0	3243.0	11056.0	10551.0	11312.0	8386.0	8536.0	10533.0	4075.0	2125.0	7829.0	5173.0	9715.0	3169.0						
SDEV	2586.9	893.7	2987.3	2685.4	2808.7	1906.2	2110.8	3309.6	1071.6	482.3	2024.7	1262.4	2353.4	869.3						
FMAX	42616.0	35987.0	35096.0	50856.0	80174.0	50171.0	35371.0	32870.0	19192.0	29571.0	26926.0	53890.0	65172.0	55492.0						
FMIN	30467.0	32744.0	24040.0	40305.0	68862.0	41785.0	26835.0	22337.0	15117.0	27446.0	19097.0	48717.0	55457.0	52323.0						
MXYR	2002	1990	1990	1990	1993	2007	2004	2004	1992	2002	2006	1991	1992	1991						
MNYR	1989	1989	2003	2004	2006	1989	1989	1990	2003	2005	1997	1995	2005	2003						

Figure A4.4.4 Maximum, mean and minimum median monthly hydrograph of outflows, Arrow Lakes Reservoir, Regime 2 (Medium Load)



APPENDIX 4.5

Differences
Regime 2 (Medium Load) Compared to Base Case (Medium Load)

Table A4.5.1 Summary table of differences between median (50% exceedance) elevations, Mica Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	4.5	7.3	9.2	8.1	5.4	0.7	3.1	0.9	-1.7	-0.6	0.2	0.0	0.7	1.6	3.2	10.9	9.2	3	-1.7	9
1990	2.6	3.4	1.9	0.6	-2.2	-5.6	-5.3	-5.8	-5.7	-2.8	-1.6	-2.0	-2.1	-2.2	-1.6	9.2	3.4	2	-5.8	8
1991	1.2	2.2	2.1	0.4	-3.2	-6.9	-5.6	-4.1	-4.3	-5.2	-2.9	-2.3	-2.1	-2.0	-2.2	9.1	2.2	2	-6.9	6
1992	1.6	3.3	2.5	0.7	-2.2	-4.9	-6.7	-8.1	-6.5	-4.8	-3.8	-6.5	-6.2	-4.5	-2.8	11.4	3.3	2	-8.1	8
1993	-2.5	1.7	3.0	0.3	-0.3	-3.3	-6.5	-6.1	-6.6	-8.2	-6.0	-8.5	-9.7	-9.7	-3.9	12.7	3.0	3	-9.7	13
1994	-13.3	-15.4	-15.4	-17.3	-16.2	-16.6	-19.7	-21.8	-21.4	-15.5	-16.8	-17.7	-17.9	-19.7	-17.0	8.5	-13.3	1	-21.8	8
1995	-21.9	-24.0	-22.4	-22.5	-23.4	-22.6	-20.5	-22.0	-22.8	-18.8	-16.9	-16.1	-16.9	-18.5	-20.0	7.9	-16.1	12	-24.0	2
1996	-21.4	-22.1	-23.5	-22.5	-21.7	-21.4	-22.5	-23.2	-22.5	-18.6	-17.7	-16.5	-16.9	-17.5	-20.7	7.0	-16.5	12	-23.5	3
1997	-21.7	-22.5	-23.4	-22.2	-19.7	-19.2	-21.2	-21.9	-23.0	-17.3	-15.7	-13.0	-13.8	-14.6	-19.4	10.4	-13.0	12	-23.4	3
1998	-18.0	-19.0	-20.5	-20.9	-20.3	-19.3	-18.0	-18.0	-17.3	-15.6	-13.6	-9.6	-11.8	-13.1	-17.1	11.3	-9.6	12	-20.9	4
1999	-15.4	-16.9	-18.2	-18.5	-18.6	-16.9	-16.9	-17.0	-16.6	-14.5	-11.3	-12.1	-11.6	-12.8	-15.7	7.3	-11.3	11	-18.6	5
2000	-15.6	-18.2	-19.0	-19.0	-18.6	-16.7	-15.3	-16.7	-16.4	-13.8	-10.0	-5.4	-5.7	-6.0	-14.5	13.6	-5.4	12	-19.0	3
2001	-10.2	-14.2	-17.9	-19.0	-18.9	-19.4	-20.1	-20.0	-19.2	-18.5	-14.6	-12.6	-13.8	-15.1	-16.6	9.9	-10.2	1	-20.1	7
2002	-18.9	-21.3	-24.4	-23.2	-23.9	-25.4	-26.5	-27.3	-26.8	-21.7	-18.0	-18.3	-19.6	-20.8	-22.4	9.3	-18.0	11	-27.3	8
2003	-24.4	-24.5	-24.9	-23.5	-23.9	-23.0	-24.2	-24.3	-25.0	-18.1	-15.6	-13.5	-15.0	-16.2	-21.3	11.5	-13.5	12	-25.0	9
2004	-19.0	-19.5	-20.8	-20.7	-20.0	-19.7	-19.4	-19.3	-19.3	-13.7	-11.0	-9.2	-10.9	-11.7	-17.0	11.6	-9.2	12	-20.8	3
2005	-16.1	-19.0	-19.2	-20.5	-20.9	-20.8	-21.5	-22.1	-22.7	-17.0	-14.9	-11.8	-14.6	-16.0	-18.3	10.9	-11.8	12	-22.7	9
2006	-21.0	-23.0	-24.8	-23.9	-25.1	-25.5	-27.2	-27.3	-27.8	-23.1	-19.4	-18.2	-18.5	-19.6	-23.1	9.6	-18.2	12	-27.8	9
2007	-23.5	-24.5	-24.9	-24.2	-25.6	-24.9	-27.1	-28.1	-26.8	-21.8	-18.5	-16.0	-16.2	-17.3	-22.9	12.1	-16.0	12	-28.1	8
2008	-22.3	-24.5	-24.9	-25.4	-26.1	-24.4	-25.0	-26.4	-25.9	-20.4	-19.2	-12.9	-14.2	-15.3	-22.2	13.5	-12.9	12	-26.4	8
AVG	-13.8	-14.5	-15.3	-15.7	-16.3	-16.8	-17.3	-17.9	-17.9	-14.5	-12.4	-11.1	-11.8	-12.6						
RNG	28.9	31.8	34.1	33.5	31.5	26.2	30.3	29.0	26.1	22.5	19.6	18.3	20.3	22.4						
SDEV	9.7	11.2	11.7	10.8	9.8	8.2	8.6	8.7	8.4	6.7	6.3	5.6	5.9	6.6						
FMAX	4.5	7.3	9.2	8.1	5.4	0.7	3.1	0.9	-1.7	-0.6	0.2	0.0	0.7	1.6						
FMIN	-24.4	-24.5	-24.9	-25.4	-26.1	-25.5	-27.2	-28.1	-27.8	-23.1	-19.4	-18.3	-19.6	-20.8						
MXYR	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989						
MNYR	2003	2003	2003	2008	2008	2006	2006	2007	2006	2006	2006	2002	2002	2002						

Figure A4.5.1 Maximum, mean and minimum differences between the median (50% exceedance) hydrographs of elevations, Mica Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)

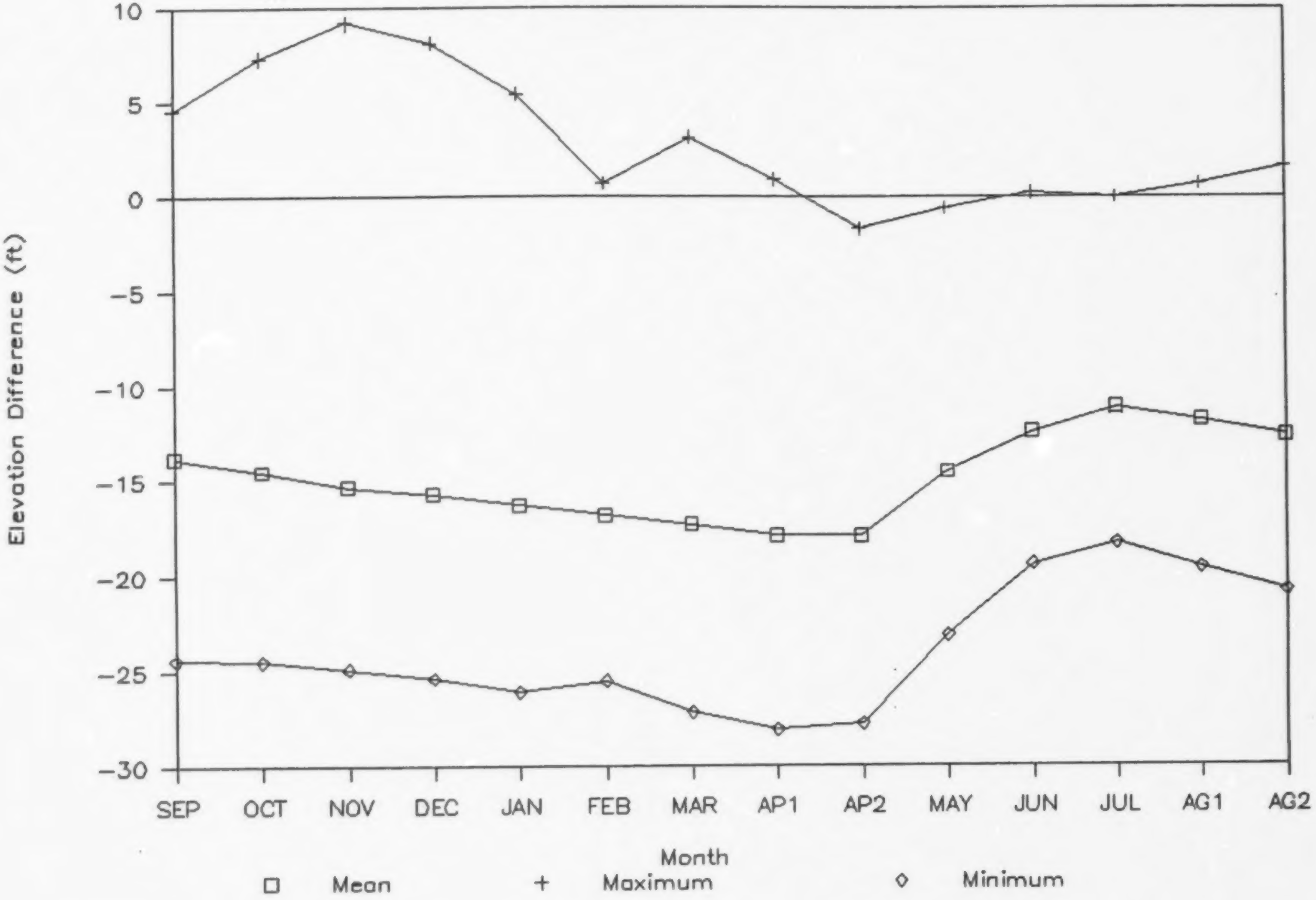


Table A4.5.2 Summary table of differences between median (50% exceedance) outflows, Mica Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	-6957.0	-2700.0	281.0	-417.0	1275.0	9919.0	0.0	0.0	0.0	0.0	0.0	-449.0	-578.0	-1104.0	9.3	16876.0	9919.0	6	-6957.0	1
1990	-3129.0	1412.0	-140.0	4823.0	0.0	599.0	0.0	0.0	0.0	0.0	0.0	960.0	-500.0	971.0	393.0	7952.0	4823.0	4	-3129.0	1
1991	-670.0	-1348.0	209.0	3720.0	-900.0	-153.0	0.0	0.0	0.0	0.0	0.0	-1100.0	-2445.0	-19.0	-122.0	6165.0	3720.0	4	-2445.0	13
1992	-3278.0	-1763.0	-272.0	2065.0	757.0	-892.0	0.0	0.0	0.0	0.0	0.0	-936.0	-639.0	607.0	-361.3	5343.0	2065.0	4	-3278.0	1
1993	-3048.0	-810.0	80.0	454.0	0.0	-583.0	-1351.0	0.0	0.0	0.0	0.0	415.0	924.0	1180.0	-315.9	4228.0	1180.0	14	-3048.0	1
1994	5340.0	3590.0	610.0	625.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-2748.0	1424.0	1112.0	723.8	8088.0	5340.0	1	-2748.0	12
1995	4990.0	2516.0	440.0	0.0	0.0	0.0	-2459.0	-1639.0	0.0	0.0	0.0	-1166.0	504.0	0.0	312.8	7449.0	4990.0	1	-2459.0	7
1996	5568.0	2893.0	1128.0	0.0	-1498.0	-1333.0	-1516.0	0.0	0.0	0.0	0.0	-3166.0	495.0	948.0	233.1	8734.0	5568.0	1	-3166.0	12
1997	5330.0	2357.0	1023.0	-46.0	-2124.0	-819.0	-695.0	0.0	0.0	0.0	0.0	-2069.0	1474.0	1112.0	354.2	7454.0	5330.0	1	-2124.0	5
1998	5408.0	1882.0	-500.0	0.0	-401.0	-951.0	-21.0	0.0	0.0	0.0	0.0	-3189.0	1777.0	1576.0	325.4	8597.0	5408.0	1	-3189.0	12
1999	5813.0	2701.0	0.0	0.0	0.0	-164.0	0.0	0.0	0.0	0.0	0.0	-3025.0	814.0	691.0	506.5	8838.0	5813.0	1	-3025.0	12
2000	5753.0	2017.0	249.0	276.0	-1608.0	-1216.0	-984.0	0.0	0.0	0.0	0.0	-3057.0	2526.0	1339.0	280.2	8810.0	5753.0	1	-3057.0	12
2001	6165.0	3590.0	1102.0	-3144.0	-371.0	0.0	0.0	0.0	0.0	0.0	0.0	-1314.0	1710.0	1680.0	643.6	9309.0	6165.0	1	-3144.0	4
2002	5834.0	3260.0	1016.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-4349.0	1747.0	1680.0	622.9	10183.0	5834.0	1	-4349.0	12
2003	4990.0	1010.0	-774.0	-2880.0	-2294.0	-1517.0	0.0	0.0	0.0	0.0	0.0	-2769.0	994.0	920.0	-273.1	7870.0	4990.0	1	-2880.0	4
2004	5920.0	1952.0	0.0	1301.0	-1495.0	-1954.0	-1008.0	0.0	0.0	0.0	0.0	-2177.0	2233.0	2607.0	413.3	8097.0	5920.0	1	-2177.0	12
2005	5900.0	3590.0	209.0	4701.0	-483.0	0.0	0.0	0.0	0.0	0.0	0.0	-4359.0	1489.0	1260.0	911.0	10259.0	5900.0	1	-4359.0	12
2006	6394.0	3189.0	1008.0	2792.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3714.0	2007.0	1445.0	949.6	10108.0	6394.0	1	-3714.0	12
2007	5340.0	1440.0	0.0	2774.0	-478.0	0.0	0.0	0.0	0.0	0.0	0.0	-4773.0	2417.0	1448.0	519.6	10113.0	5340.0	1	-4773.0	12
2008	5400.0	1789.0	0.0	0.0	-461.0	0.0	0.0	0.0	0.0	0.0	0.0	-5076.0	1881.0	675.0	244.2	10476.0	5400.0	1	-5076.0	12
AVG	3353.1	1628.3	283.5	852.2	-504.0	46.8	-401.7	-81.9	0.0	0.0	0.0	-2403.1	1008.3	1006.4						
RNG	13351.0	6290.0	1902.0	7967.0	3569.0	11873.0	2459.0	1639.0	0.0	0.0	0.0	6036.0	4971.0	3711.0						
SDEV	4155.7	1871.7	548.6	2117.0	910.1	2415.3	703.8	366.5	0.0	0.0	0.0	1688.3	1257.9	771.5						
FMAX	6394.0	3590.0	1128.0	4823.0	1275.0	9919.0	0.0	0.0	0.0	0.0	0.0	960.0	2526.0	2607.0						
FMIN	-6957.0	-2700.0	-774.0	-3144.0	-2294.0	-1954.0	-2459.0	-1639.0	0.0	0.0	0.0	-5076.0	-2445.0	-1104.0						
MXYR	2006	1994	1996	1990	1989	1989	1989	1989	1989	1989	1989	1990	2000	2004						
MNYR	1989	1989	2003	2001	2003	2004	1995	1995	1989	1989	1989	2008	1991	1989						

Figure A4.5.2 Maximum, mean and minimum differences between the median (50% exceedance) hydrographs for outflows, Mica Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)

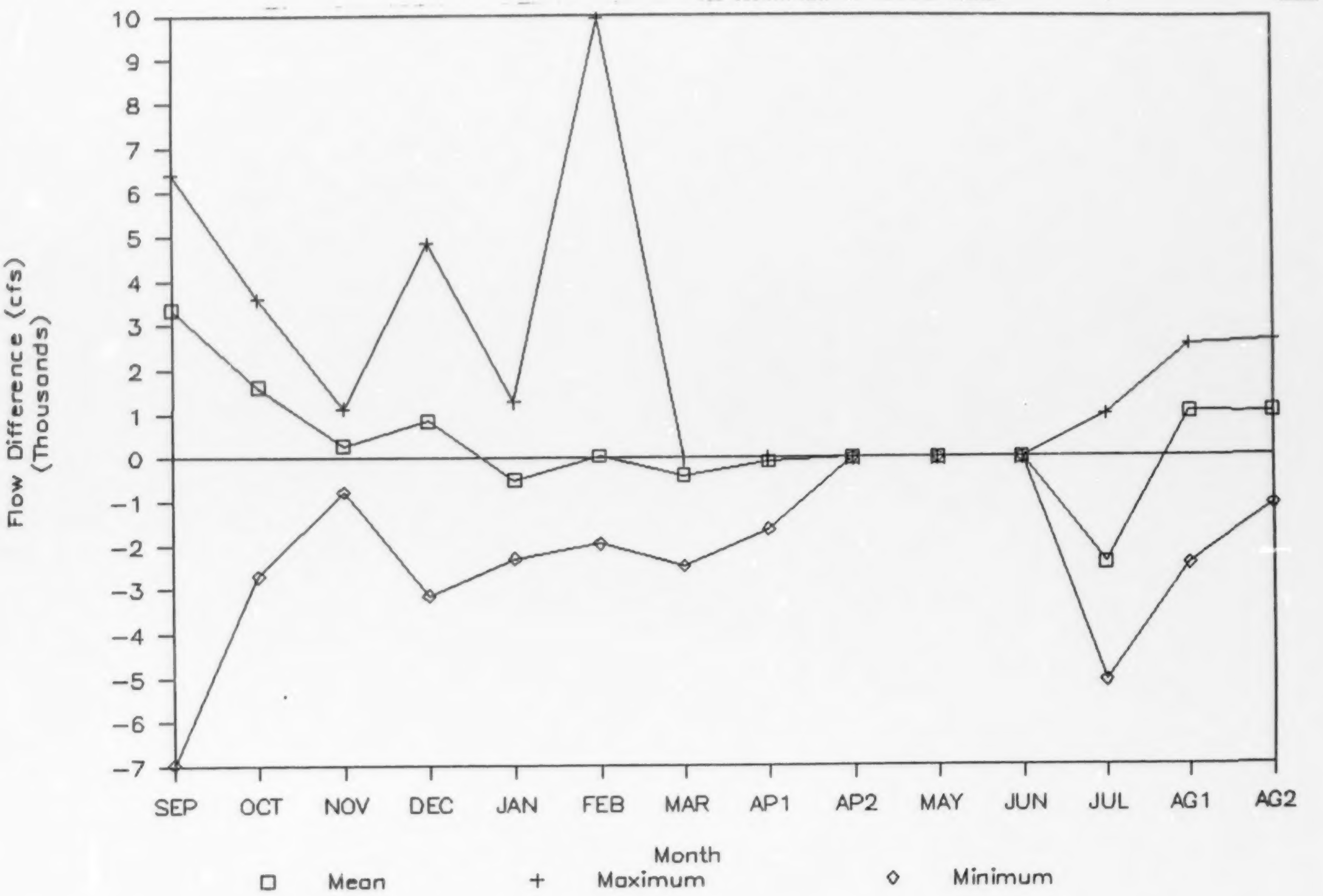


Table A4.5.3 Summary table of differences between median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	-0.9	-3.1	-0.6	-0.4	0.2	-1.4	-0.7	0.0	0.0	0.1	1.9	0.0	0.0	0.0	-0.4	5.0	1.9	11	-3.1	2
1990	0.0	0.0	-0.6	-0.2	-0.2	-0.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	1.7	7	-0.7	6
1991	0.0	0.0	-0.6	-0.5	-0.8	-0.3	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.7	0.9	7	-0.8	5
1992	-0.1	0.0	-0.6	-1.2	-1.5	-1.3	-0.7	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	-0.5	1.5	0.0	2	-1.5	5
1993	-0.2	-0.5	-0.8	-1.0	-1.0	-1.5	-0.6	0.0	0.0	0.6	0.3	0.0	0.0	0.0	-0.4	2.1	0.6	10	-1.5	6
1994	0.1	0.6	-0.6	-1.0	-0.6	-0.6	0.0	0.0	2.1	0.6	0.9	0.0	0.0	0.0	0.0	3.1	2.1	9	-1.0	4
1995	0.2	0.5	-0.9	-1.1	-0.1	0.0	0.1	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.5	9	-1.1	4
1996	0.1	0.0	-1.3	-0.1	-0.5	-1.1	0.0	0.0	1.2	1.1	0.2	0.0	0.0	0.0	-0.1	2.5	1.2	9	-1.3	3
1997	0.1	0.0	-0.9	-0.6	-0.4	-0.7	0.0	0.0	1.0	-0.1	-0.3	0.0	0.0	0.0	-0.2	1.9	1.0	9	-0.9	3
1998	0.1	0.2	-0.9	-1.3	-0.4	-1.2	0.3	0.0	0.4	0.0	0.5	0.0	0.0	0.0	-0.2	1.8	0.5	11	-1.3	4
1999	0.0	-0.1	-0.5	-0.5	-0.5	0.0	0.0	0.0	-0.5	-0.1	0.0	0.0	0.0	0.0	-0.2	0.5	0.0	1	-0.5	3
2000	0.0	0.0	-0.6	0.0	-0.6	0.4	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	2.2	1.6	9	-0.6	3
2001	0.1	0.4	-1.0	0.0	-0.9	-1.0	0.0	0.0	0.6	0.0	0.7	0.0	0.0	0.0	-0.1	1.7	0.7	11	-1.0	3
2002	0.1	0.2	-0.8	-1.1	0.1	-0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	-0.2	1.4	0.3	11	-1.1	4
2003	0.1	-0.1	-0.4	-0.1	-0.5	-1.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	-0.2	1.2	0.2	11	-1.0	6
2004	0.1	0.0	-1.1	0.0	-0.6	-0.7	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	-0.2	1.7	0.6	9	-1.1	3
2005	0.1	0.0	-1.0	0.0	-0.8	-0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-0.2	1.1	0.1	1	-1.0	3
2006	0.1	0.0	-0.8	0.0	-0.5	-0.3	0.0	0.0	0.0	-0.1	-0.3	0.0	0.0	0.0	-0.2	0.9	0.1	1	-0.8	3
2007	0.1	-0.2	-0.7	0.0	-0.5	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.8	0.1	1	-0.7	3
2008	0.0	-0.1	-0.2	0.0	-0.5	-1.9	0.0	0.0	0.6	-0.3	0.2	0.0	0.0	0.0	-0.2	2.5	0.6	9	-1.9	6
AVG	0.0	-0.1	-0.7	-0.5	-0.5	-0.7	0.1	0.0	0.5	0.1	0.3	0.0	0.0	0.0						
RNG	1.1	3.7	1.1	1.3	1.7	2.3	2.4	0.0	2.6	1.7	2.2	0.0	0.0	0.0						
SDEV	0.2	0.7	0.3	0.5	0.4	0.6	0.5	0.0	0.7	0.4	0.5	0.0	0.0	0.0						
FMAX	0.2	0.6	-0.2	0.0	0.2	0.4	1.7	0.0	2.1	1.1	1.9	0.0	0.0	0.0						
FMIN	-0.9	-3.1	-1.3	-1.3	-1.5	-1.9	-0.7	0.0	-0.5	-0.6	-0.3	0.0	0.0	0.0						
MXYR	1995	1994	2008	2000	1989	2000	1990	1989	1994	1996	1989	1989	1989	1989						
MNYR	1989	1989	1996	1998	1992	2008	1989	1989	1999	1992	1997	1989	1989	1989						

Figure A4.5.3 Maximum, mean and minimum differences between the median (50% exceedance) hydrographs of elevations, Arrow Lakes Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)

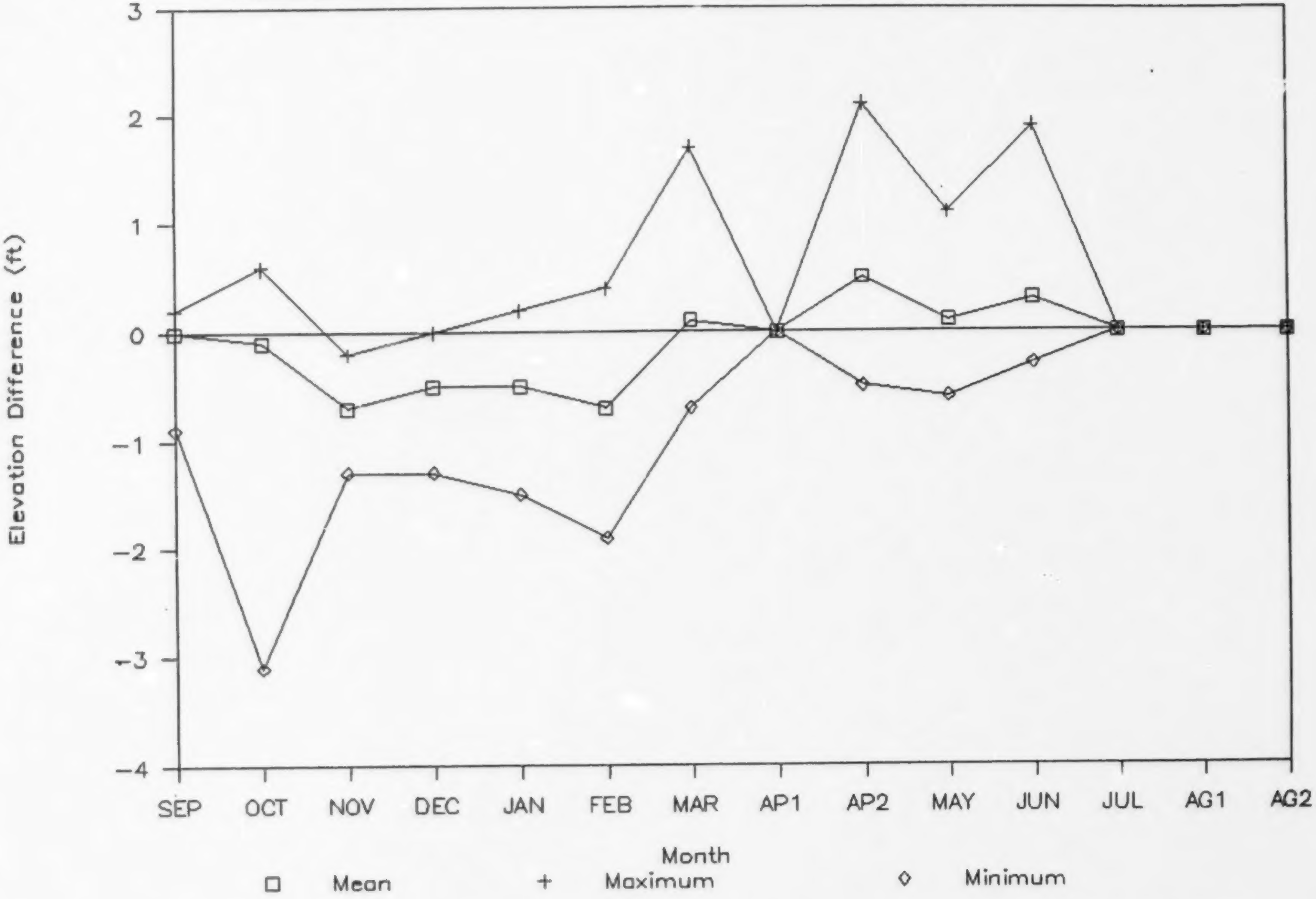
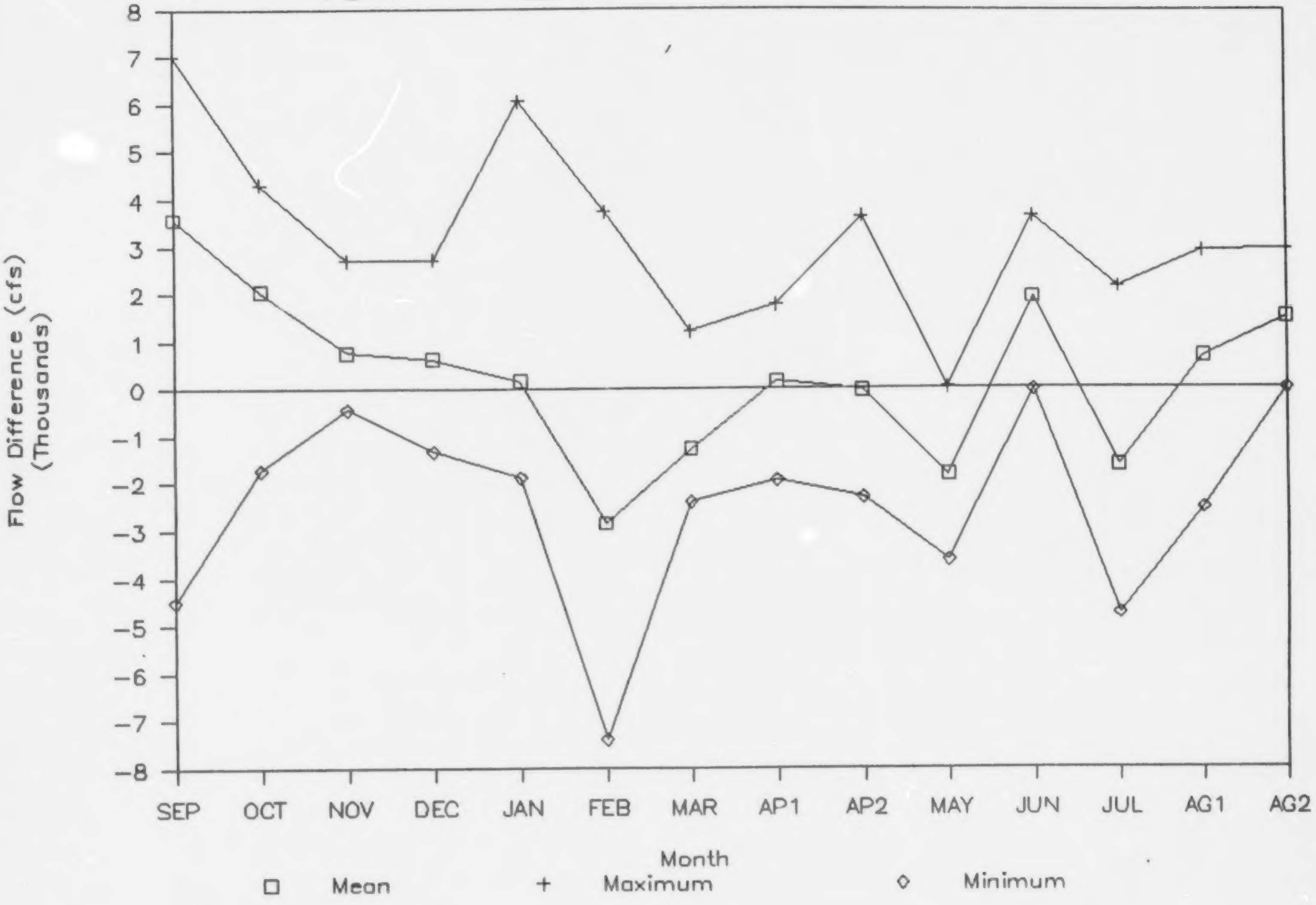


Table A4.5.4 Summary table of differences between median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	-4511.0	-535.0	-177.0	-749.0	2216.0	3717.0	-1222.0	0.0	3241.0	43.0	-31.0	2126.0	-2538.0	1310.0	157.0	8228.0	3717.0	6	-4511.0	1
1990	-2877.0	1009.0	2710.0	2574.0	6052.0	2455.0	121.0	-149.0	1838.0	0.0	3619.0	1073.0	-430.0	350.0	1461.7	8929.0	6052.0	5	-2877.0	1
1991	-2075.0	107.0	685.0	969.0	303.0	941.0	-386.0	204.0	2218.0	-69.0	2213.0	-114.0	-200.0	0.0	307.1	4293.0	2218.0	9	-2075.0	1
1992	-3051.0	-1720.0	168.0	2719.0	2474.0	1808.0	-1253.0	0.0	1395.0	-45.0	1277.0	-381.0	0.0	349.0	239.0	5770.0	2719.0	4	-3051.0	1
1993	-3341.0	-1578.0	927.0	1823.0	1655.0	1255.0	1193.0	1610.0	3607.0	-797.0	2272.0	-1816.0	1547.0	2070.0	500.8	6948.0	3607.0	9	-3341.0	1
1994	5086.0	2555.0	1831.0	2000.0	-1224.0	312.0	348.0	622.0	-1689.0	-1886.0	3379.0	-782.0	1584.0	1590.0	1056.0	6972.0	5086.0	1	-1886.0	10
1995	5130.0	1397.0	644.0	1219.0	-1020.0	-1842.0	-1841.0	806.0	-2303.0	-1924.0	1765.0	-2078.0	69.0	1306.0	115.8	7433.0	5130.0	1	-2303.0	9
1996	4806.0	2737.0	1067.0	1875.0	-10.0	-6364.0	-1947.0	1764.0	-1641.0	-3303.0	1819.0	-4743.0	1464.0	2513.0	-167.8	11170.0	4806.0	1	-6364.0	6
1997	5229.0	1783.0	827.0	596.0	-1037.0	-7388.0	-785.0	-210.0	-274.0	-3084.0	931.0	-1993.0	401.0	1058.0	-369.5	12617.0	5229.0	1	-7388.0	6
1998	6171.0	2787.0	189.0	0.0	-1168.0	-5783.0	-2044.0	630.0	-499.0	-3621.0	1528.0	-1133.0	2411.0	2922.0	-28.5	11954.0	6171.0	1	-5783.0	6
1999	4671.0	3028.0	1162.0	-168.0	-673.0	-7226.0	-2331.0	0.0	-358.0	-2260.0	2546.0	-1993.0	-1673.0	2020.0	-270.8	11897.0	4671.0	1	-7226.0	6
2000	6302.0	3384.0	-116.0	-699.0	-1872.0	-6113.0	-1082.0	-1933.0	-31.0	-2245.0	1754.0	-3795.0	1179.0	1908.0	-326.7	12415.0	6302.0	1	-6113.0	6
2001	7018.0	3826.0	1199.0	-308.0	1124.0	-4694.0	-2389.0	-1379.0	0.0	-1093.0	2529.0	-1380.0	2213.0	2280.0	615.8	11712.0	7018.0	1	-4694.0	6
2002	6413.0	3606.0	1173.0	-45.0	-772.0	-359.0	-1643.0	0.0	-604.0	-1018.0	989.0	-1266.0	2382.0	1973.0	746.1	8056.0	6413.0	1	-1643.0	7
2003	5373.0	1927.0	-423.0	-650.0	-1516.0	-6918.0	-2244.0	0.0	-2230.0	-3318.0	223.0	-106.0	-24.0	793.0	-698.5	12291.0	5373.0	1	-6918.0	6
2004	6175.0	1896.0	598.0	-1322.0	7.0	-4805.0	-1820.0	0.0	-1103.0	-1221.0	2424.0	-4583.0	2881.0	1938.0	-66.1	10980.0	6175.0	1	-4805.0	6
2005	6393.0	4316.0	667.0	1055.0	-655.0	-6332.0	-1998.0	1586.0	-156.0	-2816.0	3120.0	-4000.0	998.0	1618.0	397.8	12725.0	6393.0	1	-6332.0	6
2006	6213.0	3916.0	1353.0	1141.0	-38.0	-4787.0	-1152.0	0.0	-31.0	-3247.0	2263.0	-434.0	797.0	1228.0	518.8	11000.0	6213.0	1	-4787.0	6
2007	5877.0	3319.0	584.0	492.0	-602.0	-1550.0	-1953.0	-553.0	-1387.0	-2158.0	1716.0	-4746.0	-554.0	1978.0	60.1	10623.0	5877.0	1	-4746.0	12
2008	6305.0	3020.0	419.0	293.0	360.0	-3114.0	-982.0	72.0	-530.0	-2186.0	1978.0	-3483.0	778.0	675.0	259.0	9788.0	6305.0	1	-3483.0	12
AVG	3565.4	2039.0	774.3	640.8	180.2	-2839.4	-1270.5	153.5	-26.9	-1812.4	1915.7	-1631.3	664.3	1493.9						
RNG	11529.0	6036.0	3133.0	4041.0	7924.0	11105.0	3582.0	3697.0	5910.0	3664.0	3650.0	6872.0	5419.0	2922.0						
SDEV	4055.9	1780.0	720.8	1158.8	1833.2	3657.4	971.1	895.6	1683.2	1225.3	946.0	1882.4	1385.5	778.1						
FMAX	7018.0	4316.0	2710.0	2719.0	6052.0	3717.0	1193.0	1764.0	3607.0	43.0	3619.0	2126.0	2881.0	2922.0						
FMIN	-4511.0	-1720.0	-423.0	-1322.0	-1872.0	-7388.0	-2389.0	-1933.0	-2303.0	-3621.0	-31.0	-4746.0	-2538.0	0.0						
MXYR	2001	2005	1990	1992	1990	1989	1993	1996	1993	1989	1990	1989	2004	1998						
MNYR	1989	1992	2003	2004	2000	1997	2001	2000	1995	1998	1989	2007	1989	1991						

Figure A4.5.4 Maximum, mean and minimum differences between the median (50% exceedance) hydrographs for outflows, Arrow Lakes Reservoir, Regime 2 (Medium Load) - Base Case (Medium Load)



APPENDIX 5

Alternate Resource Order (ARO) Energy Load Scenario Summary Tables and Hydrographs

5.1 Base Case (ARO)
5.2 Regime 1 (ARO)
5.3 Differences: Regime 1 (ARO) Compared to Base Case (ARO)

APPENDIX 5.1

Base Case (ARO)

Table A5.1.1 Summary table of median (50% exceedance) elevations, Mica Reservoir, Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN
1989	2455.6	2453.6	2447.5	2428.6	2417.6	2412.2	2398.8	2396.4	2398.7	2410.1	2441.9	2470.8	2471.8	2472.0	2433.0	75.6	2472.0	14	2396.4
1990	2468.5	2465.2	2458.0	2439.3	2427.4	2420.5	2407.8	2403.6	2403.9	2418.6	2446.0	2471.8	2473.6	2473.2	2441.7	70.0	2473.6	13	2403.6
1991	2468.1	2463.8	2455.5	2439.9	2427.4	2419.4	2406.5	2402.1	2401.0	2416.4	2444.7	2470.9	2473.8	2472.5	2440.6	72.8	2473.8	13	2401.0
1992	2466.1	2460.6	2453.8	2441.2	2429.4	2421.9	2410.4	2406.9	2404.7	2417.7	2444.9	2471.8	2472.0	2472.9	2441.3	68.2	2472.9	14	2404.7
1993	2466.3	2459.5	2452.2	2439.1	2423.4	2411.3	2399.3	2391.6	2393.3	2409.5	2441.0	2465.5	2470.0	2471.4	2435.9	79.8	2471.4	14	2391.6
1994	2471.5	2469.6	2462.8	2450.4	2436.0	2423.4	2409.8	2403.2	2402.8	2417.3	2445.5	2469.9	2473.6	2475.0	2444.5	72.2	2475.0	14	2402.8
1995	2475.0	2473.1	2468.5	2455.5	2440.5	2427.3	2412.0	2404.5	2404.9	2419.1	2447.1	2469.9	2473.6	2475.0	2447.3	70.5	2475.0	1	2404.5
1996	2475.0	2473.1	2469.5	2455.9	2440.8	2427.6	2413.8	2405.9	2405.6	2419.5	2448.0	2469.9	2473.6	2475.0	2447.8	69.4	2475.0	1	2405.6
1997	2475.0	2473.1	2469.7	2456.4	2441.8	2429.0	2415.1	2407.7	2407.5	2419.5	2448.0	2469.9	2473.6	2475.0	2448.3	67.5	2475.0	1	2407.5
1998	2475.0	2473.1	2469.7	2456.2	2441.5	2428.5	2413.9	2405.9	2405.6	2418.9	2448.0	2469.9	2473.6	2475.0	2447.9	69.4	2475.0	1	2405.6
1999	2475.0	2473.1	2469.7	2456.3	2441.8	2428.6	2414.4	2407.4	2406.6	2419.5	2448.3	2469.9	2473.6	2475.0	2448.2	68.4	2475.0	1	2406.6
2000	2475.0	2473.1	2469.7	2456.6	2442.1	2429.6	2415.8	2409.0	2409.2	2422.5	2451.4	2469.9	2473.6	2475.0	2449.1	66.0	2475.0	1	2409.0
2001	2475.0	2473.1	2469.7	2456.6	2441.9	2429.2	2415.5	2407.8	2407.5	2419.7	2448.3	2469.9	2473.6	2475.0	2448.4	67.5	2475.0	1	2407.5
2002	2475.0	2473.1	2469.7	2456.4	2441.8	2429.0	2414.6	2407.7	2407.0	2421.8	2448.5	2469.9	2473.6	2475.0	2448.5	68.0	2475.0	1	2407.0
2003	2475.0	2473.1	2469.7	2456.5	2442.0	2429.3	2415.5	2407.7	2407.6	2422.1	2449.1	2469.9	2473.6	2475.0	2448.7	67.4	2475.0	1	2407.6
2004	2475.0	2473.1	2469.7	2456.6	2442.4	2429.6	2415.8	2408.6	2408.7	2422.5	2451.4	2469.9	2473.6	2475.0	2449.1	66.4	2475.0	1	2408.6
2005	2475.0	2473.1	2469.7	2456.6	2442.4	2429.6	2415.8	2408.6	2408.6	2421.9	2448.5	2469.9	2473.6	2475.0	2448.8	66.4	2475.0	1	2408.6
2006	2475.0	2473.1	2469.7	2457.6	2443.2	2429.9	2416.6	2409.6	2409.2	2424.4	2450.5	2469.9	2473.6	2475.0	2449.5	65.8	2475.0	1	2409.2
2007	2475.0	2473.1	2469.7	2457.3	2442.9	2430.1	2416.4	2409.6	2409.2	2421.9	2448.8	2469.9	2473.6	2475.0	2449.1	65.8	2475.0	1	2409.2
2008	2475.0	2473.1	2469.7	2459.1	2444.4	2431.1	2417.0	2410.0	2410.2	2422.4	2451.4	2469.9	2473.6	2475.0	2449.8	65.0	2475.0	1	2410.0
AVG	2472.3	2469.8	2465.2	2451.6	2437.5	2425.9	2412.2	2405.7	2405.6	2419.3	2447.6	2470.0	2473.3	2474.4					
RNG	19.4	19.5	22.2	30.5	26.8	19.8	18.2	18.4	16.9	14.9	10.4	6.3	3.8	3.6					
SDEV	5.1	5.9	7.4	8.8	7.9	5.9	5.4	4.6	4.1	3.8	2.9	1.2	0.9	1.2					
FMAX	2475.0	2473.1	2469.7	2459.1	2444.4	2431.1	2417.0	2410.0	2410.2	2424.4	2451.4	2471.8	2473.8	2475.0					
FMIN	2455.6	2453.6	2447.5	2428.6	2417.6	2411.3	2398.8	2391.6	2393.3	2409.5	2441.0	2465.5	2470.0	2471.4					
MXYR	1995	1995	1997	2008	2008	2008	2008	2008	2008	2006	2000	1990	1991	1994					
MNYR	1989	1989	1989	1989	1989	1993	1989	1993	1993	1993	1993	1993	1993	1993					

Figure A5.1.1 Maximum, mean and minimum median monthly hydrograph of elevations, Mica Reservoir, Base Case (ARO)

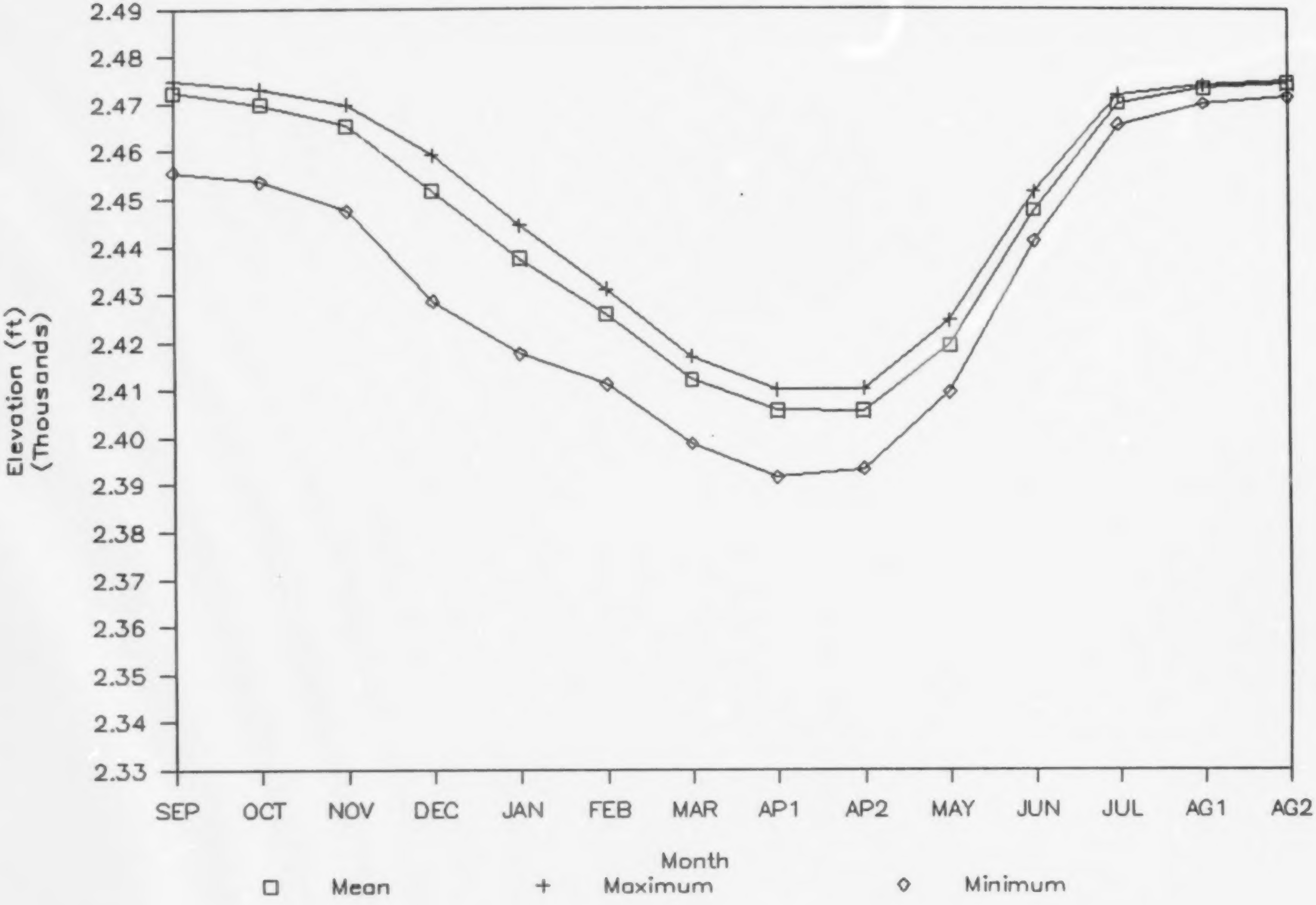


Table A5.1.2 Summary table of median (50% exceedance) outflows, Mica Reservoir, Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	20518.0	14350.0	17195.0	34000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	10000.0	21633.0	34578.0	33626.0	10541.6	24578.0	34578.0	13	10000.0	9
1990	25006.0	16414.0	19466.0	20033.0	26000.0	22015.0	17000.0	15000.0	10000.0	10000.0	10000.0	26304.0	36407.0	33717.0	20716.7	26407.0	36407.0	13	10000.0	9
1991	27000.0	17084.0	19109.0	27504.0	26345.0	22534.0	20000.0	15000.0	10000.0	10000.0	10000.0	25995.0	36416.0	37779.0	21264.0	27779.0	37779.0	14	10000.0	9
1992	29967.0	18512.0	19032.0	23000.0	21689.0	18356.0	18000.0	18000.0	18000.0	10000.0	10000.0	27314.0	40639.0	34107.0	20936.9	30639.0	40639.0	13	10000.0	10
1993	30389.0	19150.0	17734.0	27000.0	27000.0	25000.0	23000.0	26077.0	10000.0	10000.0	10000.0	23975.0	32576.0	32037.0	21999.4	22576.0	32576.0	13	10000.0	9
1994	21098.0	14750.0	15058.0	27000.0	27000.0	25000.0	23000.0	26590.0	10000.0	10000.0	10000.0	26707.0	32576.0	32037.0	20851.2	22576.0	32576.0	13	10000.0	9
1995	20838.0	14750.0	14898.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	24231.0	32016.0	32037.0	20637.0	22016.0	32016.0	13	10000.0	9
1996	20838.0	15080.0	14898.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28018.0	33006.0	32269.0	20997.6	23006.0	33006.0	13	10000.0	9
1997	21038.0	15420.0	14277.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	26028.0	32996.0	32037.0	20815.0	22996.0	32996.0	13	10000.0	9
1998	21038.0	15080.0	14898.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28850.0	32996.0	32037.0	21073.5	22996.0	32996.0	13	10000.0	9
1999	21038.0	15310.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	32996.0	32457.0	20897.7	22996.0	32996.0	13	10000.0	9
2000	20518.0	15080.0	14198.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30877.0	33006.0	32457.0	20742.0	23006.0	33006.0	13	10000.0	9
2001	21238.0	14750.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	32996.0	32037.0	20850.2	22996.0	32996.0	13	10000.0	9
2002	21038.0	15080.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28877.0	32996.0	32037.0	21017.5	22996.0	32996.0	13	10000.0	9
2003	21038.0	14750.0	13989.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	33006.0	32037.0	20816.5	23006.0	33006.0	13	10000.0	9
2004	20518.0	15080.0	13989.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30677.0	33006.0	32560.0	20712.3	23006.0	33006.0	13	10000.0	9
2005	21038.0	14750.0	13989.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28975.0	32996.0	32457.0	20581.5	22996.0	32996.0	13	10000.0	9
2006	21038.0	14750.0	13243.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30173.0	33406.0	32560.0	20640.6	23406.0	33406.0	13	10000.0	9
2007	21098.0	15150.0	14198.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28975.0	32996.0	32269.0	20629.5	22996.0	32996.0	13	10000.0	9
2008	21038.0	15080.0	14198.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30876.0	33406.0	32527.0	20804.9	23406.0	33406.0	13	10000.0	9
AVG	22406.5	15518.5	15348.2	25726.8	26353.5	23653.5	22000.0	24723.3	10400.0	10000.0	10000.0	27474.3	33790.0	32754.1						
RNG	9871.0	4800.0	6223.0	12000.0	5964.0	14835.0	6000.0	12000.0	8000.0	0.0	0.0	9244.0	8063.0	5742.0						
SDEV	3153.4	1290.7	1967.2	3111.1	1729.7	3575.9	2127.5	4642.6	1788.9	0.0	0.0	2440.6	1951.2	1332.7						
FMAX	30389.0	19150.0	19466.0	34000.0	27000.0	25000.0	23000.0	27000.0	18000.0	10000.0	10000.0	30877.0	40639.0	37779.0						
FMIN	20518.0	14350.0	13243.0	22000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	10000.0	21633.0	32576.0	32037.0						
MXYR	1993	1993	1990	1989	1993	1993	1993	1995	1992	1989	1989	2000	1992	1991						
MNYR	1989	1989	2006	2000	1989	1989	1989	1989	1989	1989	1989	1989	1993	1993						

Figure A5.1.2 Maximum, mean and minimum median monthly hydrograph of outflows, Mica Reservoir, Base Case (ARO)

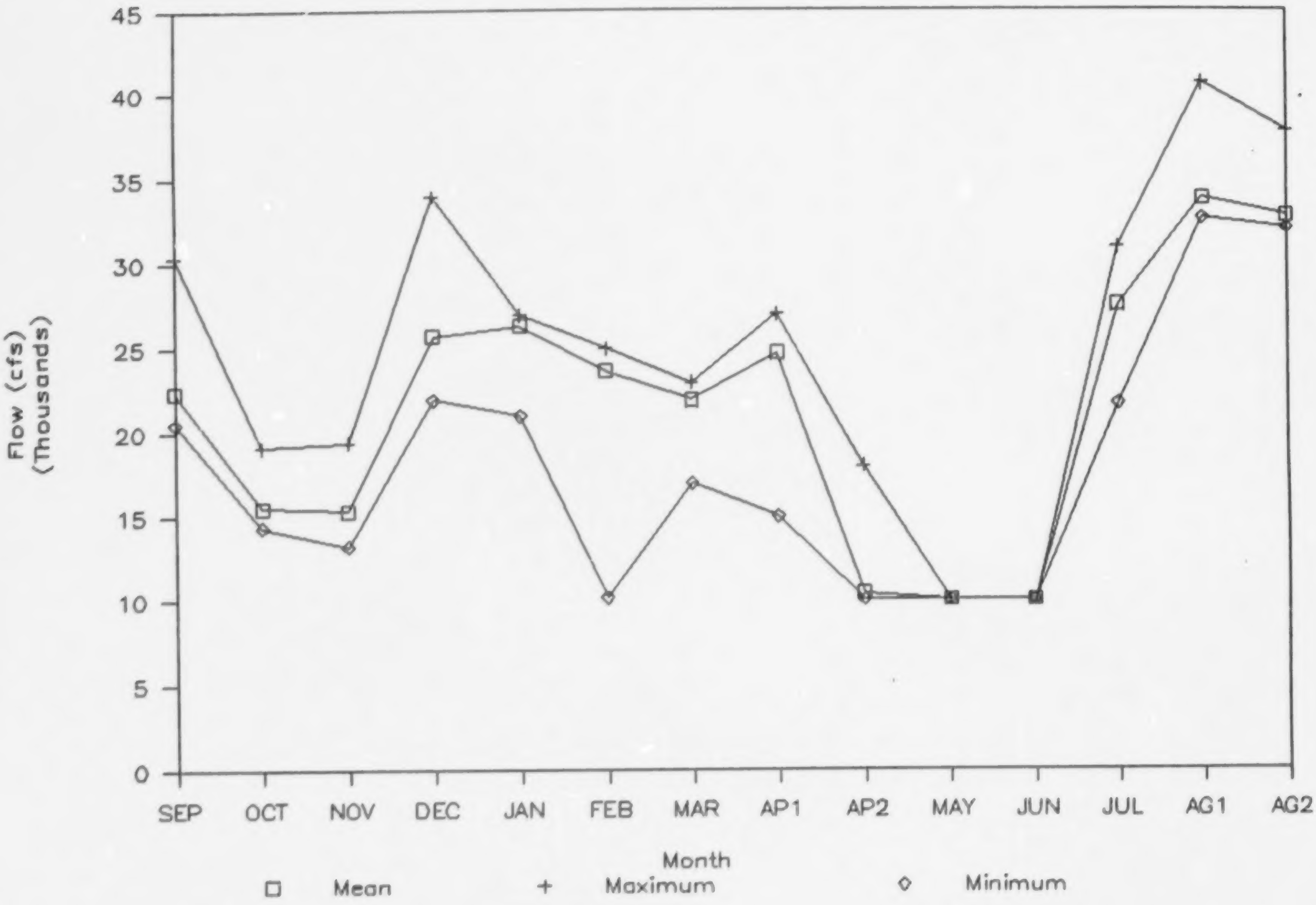


Table A5.1.3 Summary table of median (50% exceedance) elevations, Arrow Lakes Reservoir, Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	1444.0	1441.9	1438.1	1433.3	1400.9	1399.2	1399.1	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.3	44.9	1444.0	1	1399.1	7
1990	1443.9	1441.8	1438.8	1431.9	1406.3	1396.5	1396.2	1399.9	1399.9	1414.6	1435.3	1444.0	1444.0	1444.0	1424.4	47.8	1444.0	12	1396.2	7
1991	1443.8	1440.7	1439.0	1433.2	1409.2	1400.2	1398.6	1399.9	1399.9	1415.2	1437.2	1444.0	1444.0	1444.0	1425.4	45.4	1444.0	12	1398.6	7
1992	1443.8	1441.5	1439.6	1432.8	1405.9	1397.1	1396.2	1399.5	1399.9	1415.2	1437.0	1444.0	1444.0	1444.0	1424.7	47.8	1444.0	12	1396.2	7
1993	1443.8	1441.8	1439.2	1434.8	1407.9	1399.6	1398.9	1399.9	1401.4	1415.2	1435.5	1444.0	1444.0	1444.0	1425.4	45.1	1444.0	12	1398.9	7
1994	1443.7	1440.5	1439.7	1436.2	1410.9	1400.9	1399.9	1399.9	1399.9	1414.6	1435.8	1444.0	1444.0	1444.0	1425.8	44.1	1444.0	12	1399.9	7
1995	1443.5	1440.4	1440.0	1436.2	1409.7	1400.1	1398.7	1399.9	1400.6	1414.6	1435.6	1444.0	1444.0	1444.0	1425.6	45.3	1444.0	12	1398.7	7
1996	1443.6	1440.7	1440.4	1436.2	1412.3	1404.0	1399.9	1399.9	1399.9	1413.0	1436.1	1444.0	1444.0	1444.0	1426.2	44.1	1444.0	12	1399.9	7
1997	1443.7	1441.4	1440.4	1436.2	1411.0	1402.5	1399.9	1399.9	1400.9	1413.2	1435.6	1444.0	1444.0	1444.0	1426.0	44.1	1444.0	12	1399.9	7
1998	1443.7	1440.8	1439.4	1435.3	1409.3	1400.3	1399.6	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.6	44.4	1444.0	12	1399.6	7
1999	1443.8	1441.7	1439.9	1435.4	1410.2	1402.0	1399.9	1399.9	1403.3	1415.2	1437.3	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	12	1399.9	7
2000	1443.8	1441.9	1441.5	1436.2	1413.0	1403.7	1399.9	1399.9	1401.9	1415.2	1435.3	1444.0	1444.0	1444.0	1426.6	44.1	1444.0	12	1399.9	7
2001	1443.7	1441.3	1441.0	1436.2	1412.3	1403.4	1399.9	1399.9	1401.3	1415.2	1435.3	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	12	1399.9	7
2002	1443.8	1441.3	1439.9	1435.0	1410.5	1400.8	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.1	44.1	1444.0	12	1399.9	7
2003	1443.8	1441.6	1440.7	1436.2	1412.4	1404.5	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	12	1399.9	7
2004	1443.8	1441.9	1441.6	1436.2	1413.3	1404.3	1399.9	1399.9	1401.3	1415.2	1437.3	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	12	1399.9	7
2005	1443.8	1441.6	1441.6	1436.2	1413.3	1405.0	1399.9	1399.9	1403.4	1415.2	1437.4	1444.0	1444.0	1444.0	1427.0	44.1	1444.0	12	1399.9	7
2006	1443.8	1441.9	1441.7	1436.2	1413.8	1406.7	1399.9	1399.9	1403.9	1415.3	1435.6	1444.0	1444.0	1444.0	1427.1	44.1	1444.0	12	1399.9	7
2007	1443.8	1441.9	1441.7	1436.2	1411.1	1402.3	1399.9	1399.9	1403.4	1415.2	1436.1	1444.0	1444.0	1444.0	1426.5	44.1	1444.0	12	1399.9	7
2008	1443.9	1441.8	1442.1	1436.2	1413.6	1403.6	1399.4	1399.9	1401.5	1415.2	1435.6	1444.0	1444.0	1444.0	1426.7	44.6	1444.0	12	1399.4	7
AVG	1443.8	1441.4	1440.3	1435.3	1410.7	1401.8	1399.3	1399.9	1401.5	1414.9	1436.2	1444.0	1444.0	1444.0						
RNG	0.5	1.5	4.0	4.3	7.9	10.2	3.7	0.4	4.0	2.3	2.1	0.0	0.0	0.0						
SDEV	0.1	0.5	1.1	1.4	2.3	2.7	1.1	0.1	1.5	0.7	0.8	0.0	0.0	0.0						
FMAX	1444.0	1441.9	1442.1	1436.2	1413.8	1406.7	1399.9	1399.9	1403.9	1415.3	1437.4	1444.0	1444.0	1444.0						
FMIN	1443.5	1440.4	1438.1	1431.9	1405.9	1396.5	1396.2	1399.5	1399.9	1413.0	1435.3	1444.0	1444.0	1444.0						
MXYR	1989	1989	2008	1994	2006	2006	1994	1989	2006	2006	2005	1989	1989	1989						
MNYR	1995	1995	1989	1990	1992	1990	1990	1992	1989	1996	1990	1989	1989	1989						

Figure A5.1.3 Maximum, mean and minimum median monthly hydrograph of elevations, Arrow Lakes Reservoir, Base Case (ARO)

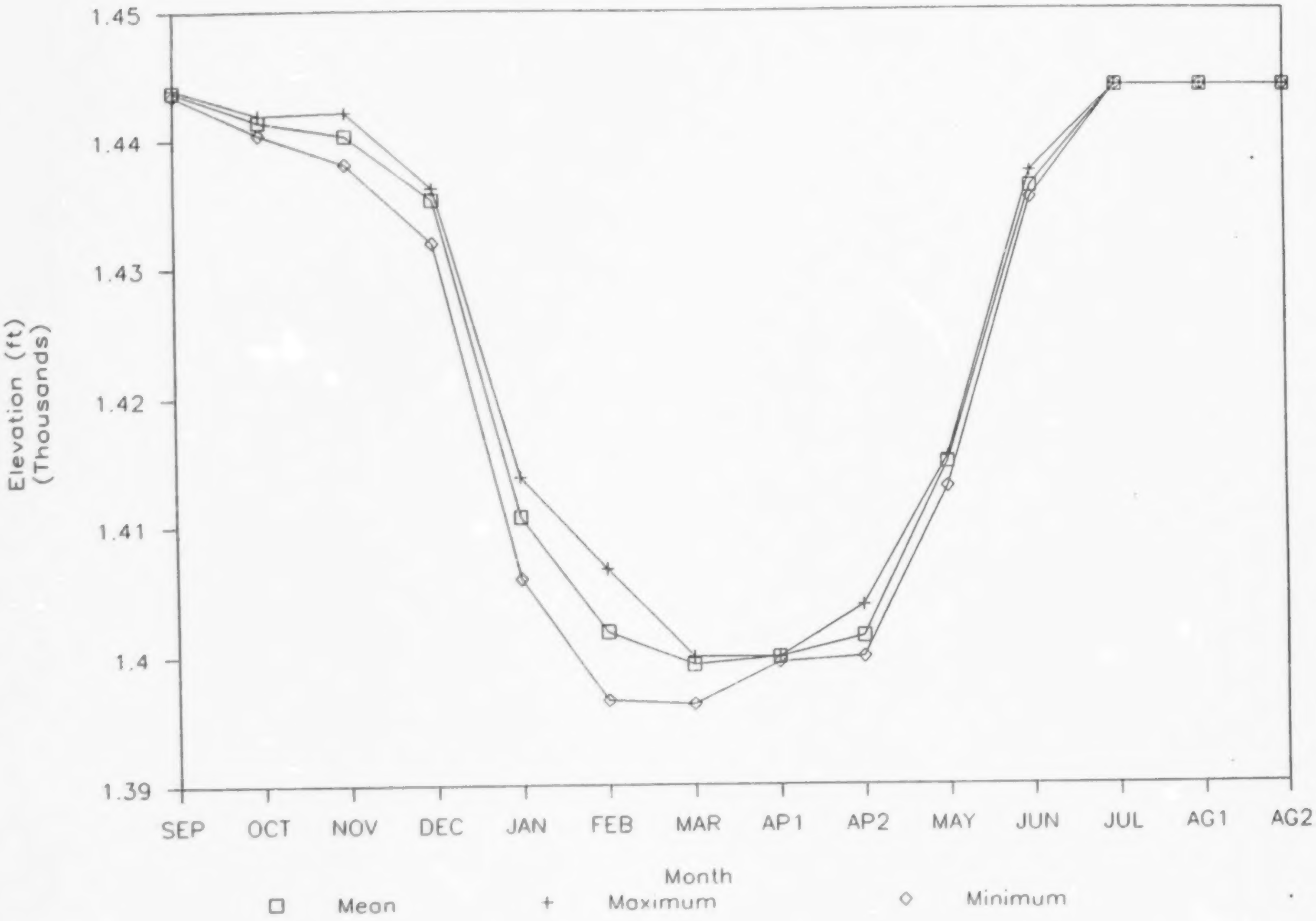
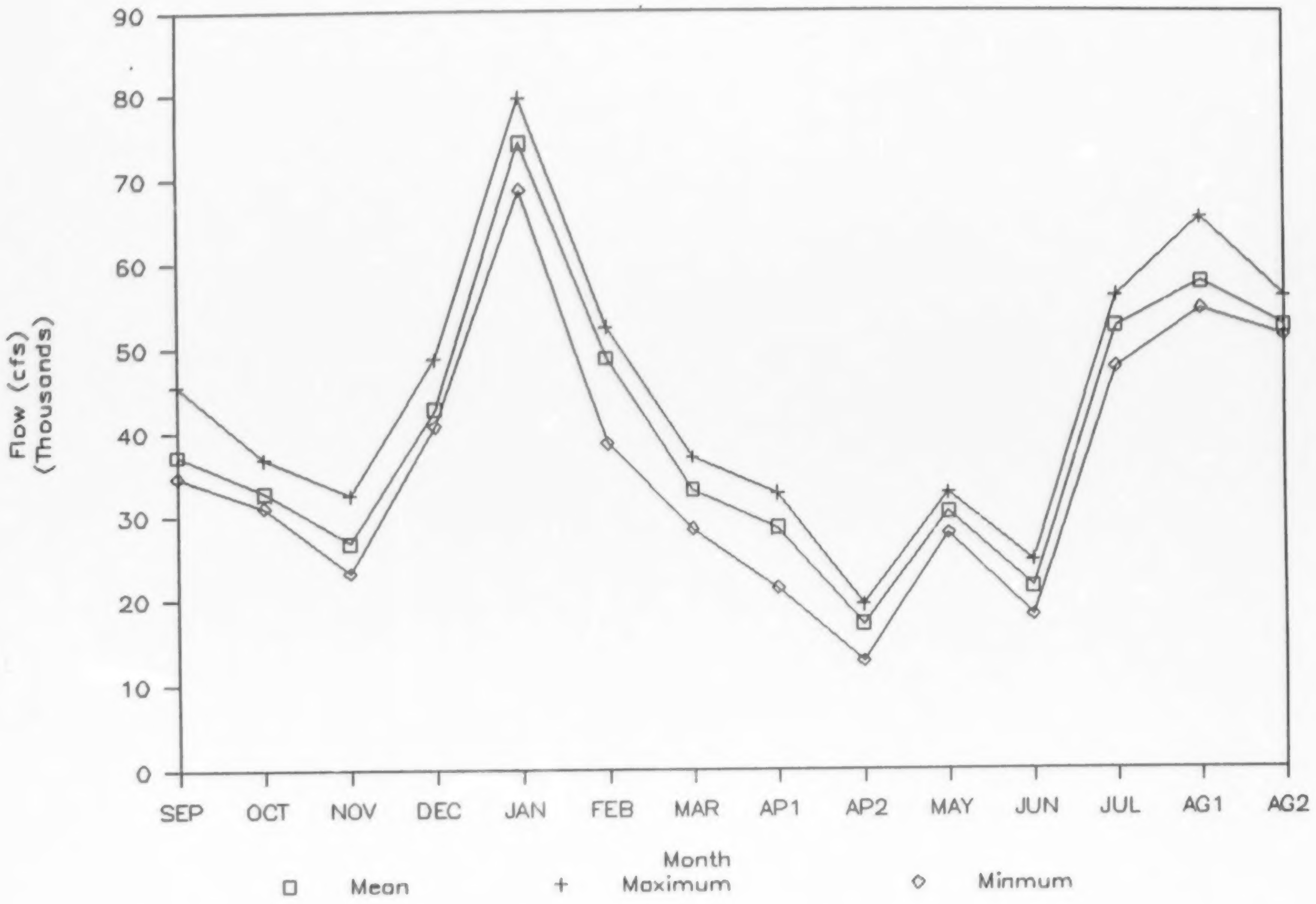


Table A5.1.4 Summary table of median (50% exceedance) outflows, Arrow Lakes Reservoir, Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	NT	MIN	NT
1989	34978.0	33209.0	32430.0	48815.0	69417.0	38842.0	28559.0	22886.0	12775.0	27982.0	21183.0	47521.0	60493.0	54162.0	38174.5	56642.0	69417.0	5	12775.0	9
1990	41824.0	35312.0	32537.0	48061.0	71203.0	44115.0	28704.0	21470.0	16693.0	28903.0	22306.0	51380.0	61474.0	53148.0	40061.5	54510.0	71203.0	5	16693.0	9
1991	42801.0	35312.0	30811.0	46527.0	73443.0	45017.0	31175.0	22486.0	14966.0	28903.0	22107.0	53679.0	59320.0	55879.0	40508.4	58477.0	73443.0	5	14966.0	9
1992	45675.0	36775.0	30108.0	44372.0	69340.0	42300.0	30710.0	24470.0	17797.0	28903.0	20821.0	50995.0	65172.0	53815.0	40052.2	51543.0	69340.0	5	17797.0	9
1993	45654.0	36949.0	29473.0	42725.0	79286.0	44067.0	30991.0	27081.0	13106.0	29573.0	22152.0	51157.0	54459.0	52659.0	40473.3	66180.0	79286.0	5	13106.0	9
1994	37009.0	33277.0	26676.0	41795.0	74320.0	47483.0	32383.0	29413.0	16799.0	30311.0	18166.0	51314.0	54629.0	51282.0	39066.3	57521.0	74320.0	5	16799.0	9
1995	36462.0	32797.0	26423.0	42050.0	79658.0	48041.0	32274.0	28596.0	17473.0	30419.0	19476.0	50795.0	56677.0	51796.0	39638.8	62185.0	79658.0	5	17473.0	9
1996	36224.0	32581.0	26153.0	41763.0	71304.0	51721.0	34718.0	30908.0	19487.0	32196.0	19476.0	55971.0	54629.0	51898.0	40047.3	51828.0	71304.0	5	19476.0	11
1997	36285.0	33327.0	26591.0	42060.0	75971.0	51721.0	32542.0	29276.0	17846.0	32336.0	18166.0	51157.0	58596.0	52870.0	39954.2	58125.0	75971.0	5	17846.0	9
1998	36040.0	32684.0	27391.0	42472.0	78303.0	51721.0	32410.0	29486.0	17846.0	32423.0	22306.0	50795.0	57104.0	51642.0	40382.0	60457.0	78303.0	5	17846.0	9
1999	36154.0	31907.0	26110.0	42255.0	74975.0	51557.0	34718.0	29486.0	17347.0	31146.0	19989.0	51157.0	58492.0	51642.0	39871.0	57628.0	74975.0	5	17347.0	9
2000	34755.0	31714.0	25320.0	41734.0	74633.0	52529.0	35973.0	32870.0	17846.0	31113.0	24140.0	55971.0	58688.0	53479.0	40777.0	56787.0	74633.0	5	17846.0	9
2001	35065.0	31598.0	25900.0	41718.0	76474.0	51721.0	34732.0	31787.0	17877.0	29779.0	21025.0	51157.0	55171.0	51452.0	39776.0	58597.0	76474.0	5	17877.0	9
2002	36412.0	32282.0	26874.0	42634.0	76139.0	46541.0	32442.0	29486.0	17347.0	30496.0	22529.0	52654.0	54459.0	51642.0	39622.5	58792.0	76139.0	5	17347.0	9
2003	34724.0	31388.0	24522.0	41763.0	74891.0	51870.0	35262.0	29486.0	17347.0	32838.0	22306.0	51421.0	58221.0	51578.0	39941.8	57544.0	74891.0	5	17347.0	9
2004	34887.0	31543.0	23865.0	41401.0	72961.0	51721.0	37088.0	32698.0	17877.0	29934.0	23518.0	55971.0	55339.0	52870.0	40190.1	55084.0	72961.0	5	17877.0	9
2005	35758.0	31200.0	24194.0	41261.0	73766.0	51721.0	34718.0	31284.0	19100.0	30403.0	22080.0	51338.0	54459.0	51642.0	39556.0	54666.0	73766.0	5	19100.0	9
2006	34808.0	31142.0	23303.0	40836.0	68759.0	49794.0	35110.0	32698.0	17877.0	32150.0	24766.0	51338.0	56352.0	51642.0	39274.2	50882.0	68759.0	5	17877.0	9
2007	36120.0	31526.0	25108.0	41806.0	78291.0	51721.0	34513.0	29486.0	17846.0	30640.0	22529.0	55849.0	58683.0	51282.0	40562.6	60445.0	78291.0	5	17846.0	9
2008	35120.0	31364.0	24140.0	41436.0	73559.0	52529.0	35555.0	29486.0	17877.0	30605.0	21761.0	55849.0	59803.0	52690.0	40153.8	55682.0	73559.0	5	17877.0	9
AVG	37337.8	32894.4	26896.4	42874.2	74334.6	48836.6	33228.9	28741.9	17156.4	30552.7	21540.1	52373.4	57611.0	52453.5						
RNG	10951.0	5807.0	9234.0	7979.0	10899.0	13687.0	8529.0	11400.0	6712.0	4856.0	6600.0	8450.0	10713.0	4597.0						
SDEV	3564.1	1812.9	2770.3	2272.9	3231.3	4058.8	2376.5	3404.1	1694.4	1350.3	1783.5	2365.1	2846.7	1192.8						
FMAX	45675.0	36949.0	32537.0	48815.0	79658.0	52529.0	37088.0	32870.0	19487.0	32838.0	24766.0	55971.0	65172.0	55879.0						
FMIN	34724.0	31142.0	23303.0	40836.0	68759.0	38842.0	28559.0	21470.0	12775.0	27982.0	18166.0	47521.0	54459.0	51282.0						
MXYR	1992	1993	1990	1989	1995	2000	2004	2000	1996	2003	2006	1996	1992	1991						
MNYR	2003	2006	2005	2006	2006	1989	1989	1990	1989	1989	1994	1989	1993	1994						

Figure A5.1.4 Maximum, mean and minimum median monthly hydrograph of outflows, Arrow Lakes Reservoir, Base Case (ARO)



APPENDIX 5.2

Regime 1 (ARO)

Table A5.2.1 Summary table of median (50% exceedance) elevations, Mica Reservoir, Regime 1 (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	2455.6	2453.6	2447.5	2428.6	2417.6	2412.2	2398.8	2396.4	2398.7	2410.1	2441.9	2470.8	2471.8	2472.0	2433.8	75.6	2472.0	14	2396.4	8
1990	2468.5	2461.1	2448.7	2428.5	2414.1	2410.2	2399.1	2396.3	2394.7	2409.2	2443.1	2467.6	2469.3	2469.5	2434.6	74.8	2469.5	14	2394.7	9
1991	2463.3	2458.7	2446.7	2427.2	2412.1	2405.1	2392.7	2388.3	2388.5	2403.2	2438.4	2464.2	2466.7	2466.4	2430.5	78.4	2466.7	13	2388.3	8
1992	2459.4	2456.2	2444.4	2427.8	2410.5	2402.3	2386.6	2383.0	2380.1	2399.2	2430.6	2457.7	2460.4	2461.0	2426.4	80.9	2461.0	14	2380.1	9
1993	2455.6	2449.9	2439.7	2422.3	2404.1	2386.4	2372.4	2363.1	2364.5	2386.7	2422.8	2449.1	2452.4	2451.9	2417.1	92.5	2455.6	1	2363.1	8
1994	2444.9	2439.1	2430.8	2415.6	2399.3	2382.5	2362.7	2354.3	2353.5	2380.1	2412.6	2438.8	2442.1	2443.5	2408.6	91.4	2444.9	1	2353.5	9
1995	2437.9	2432.6	2426.2	2411.5	2392.6	2376.8	2362.9	2352.6	2353.0	2377.6	2415.3	2441.3	2443.8	2443.9	2405.9	91.3	2443.9	14	2352.6	8
1996	2436.1	2433.0	2427.7	2413.8	2397.6	2382.9	2363.8	2355.3	2356.4	2380.4	2414.7	2441.0	2446.2	2446.1	2407.8	90.9	2446.2	13	2355.3	8
1997	2438.8	2436.1	2430.5	2417.3	2404.1	2390.5	2370.2	2362.0	2362.3	2384.1	2418.8	2446.0	2450.1	2451.5	2412.4	89.5	2451.5	14	2362.0	8
1998	2446.9	2443.3	2436.8	2425.4	2407.5	2394.0	2380.6	2374.3	2374.4	2393.7	2429.9	2455.3	2458.4	2458.4	2420.5	84.1	2458.4	13	2374.3	8
1999	2454.7	2449.7	2443.7	2430.9	2413.2	2400.4	2387.9	2379.6	2381.4	2399.6	2434.6	2457.6	2460.6	2461.9	2426.2	82.3	2461.9	14	2379.6	8
2000	2456.7	2451.4	2444.7	2432.3	2416.1	2406.1	2394.2	2387.1	2386.8	2405.8	2439.4	2464.1	2466.1	2466.2	2430.3	79.4	2466.2	14	2386.8	9
2001	2459.3	2453.8	2445.3	2432.5	2412.0	2398.4	2385.3	2378.1	2378.4	2396.2	2430.7	2455.9	2458.3	2458.3	2425.5	81.2	2459.3	1	2378.1	8
2002	2452.5	2445.5	2438.3	2425.9	2407.7	2390.4	2377.3	2368.9	2371.1	2392.9	2423.5	2449.1	2451.6	2451.8	2418.7	83.6	2452.5	1	2368.9	8
2003	2447.2	2442.1	2435.8	2424.4	2410.0	2397.3	2387.1	2379.9	2381.7	2401.0	2433.7	2456.4	2459.0	2459.4	2422.9	79.5	2459.4	14	2379.9	8
2004	2453.3	2449.5	2443.8	2429.5	2412.1	2400.2	2391.2	2384.9	2385.7	2403.7	2438.8	2460.9	2462.8	2462.5	2427.6	77.9	2462.8	13	2384.9	8
2005	2456.1	2451.1	2444.1	2428.4	2410.1	2396.0	2383.8	2376.7	2378.4	2399.9	2431.1	2455.4	2457.9	2459.0	2424.3	82.3	2459.0	14	2376.7	8
2006	2450.6	2444.9	2439.1	2422.6	2405.9	2391.9	2379.4	2371.3	2373.6	2394.2	2426.7	2452.4	2455.0	2453.6	2419.5	83.7	2455.0	13	2371.3	8
2007	2448.8	2444.5	2437.7	2423.9	2407.4	2392.5	2380.6	2373.0	2372.5	2393.2	2426.4	2451.5	2454.8	2455.1	2419.5	82.6	2455.1	14	2372.5	9
2008	2448.3	2443.8	2437.7	2422.8	2407.8	2395.4	2386.0	2377.8	2377.1	2396.2	2429.6	2455.3	2459.0	2459.7	2421.6	82.6	2459.7	14	2377.1	9
AVG	2451.7	2447.0	2439.5	2424.6	2408.1	2395.6	2382.1	2375.1	2375.6	2395.3	2429.1	2454.5	2457.3	2457.6						
RNG	32.4	28.5	22.5	21.0	25.0	35.4	36.4	43.8	45.7	32.5	30.5	32.0	29.7	28.5						
SDEV	8.4	8.0	6.7	6.0	6.3	9.3	11.2	12.9	12.8	9.5	9.1	8.7	8.1	8.0						
FMAX	2468.5	2461.1	2448.7	2432.5	2417.6	2412.2	2399.1	2396.4	2398.7	2410.1	2443.1	2470.8	2471.8	2472.0						
FMIN	2436.1	2432.6	2426.2	2411.5	2392.6	2376.8	2362.7	2352.6	2353.0	2377.6	2412.6	2438.8	2442.1	2443.5						
MXYR	1990	1990	1990	2001	1989	1989	1990	1989	1989	1989	1990	1989	1989	1989						
MNYR	1996	1995	1995	1995	1995	1995	1994	1995	1995	1995	1994	1994	1994	1994						

Figure A5.2.1 Maximum, mean and minimum median monthly hydrograph of elevations, Mica Reservoir, Regime 1 (ARO)

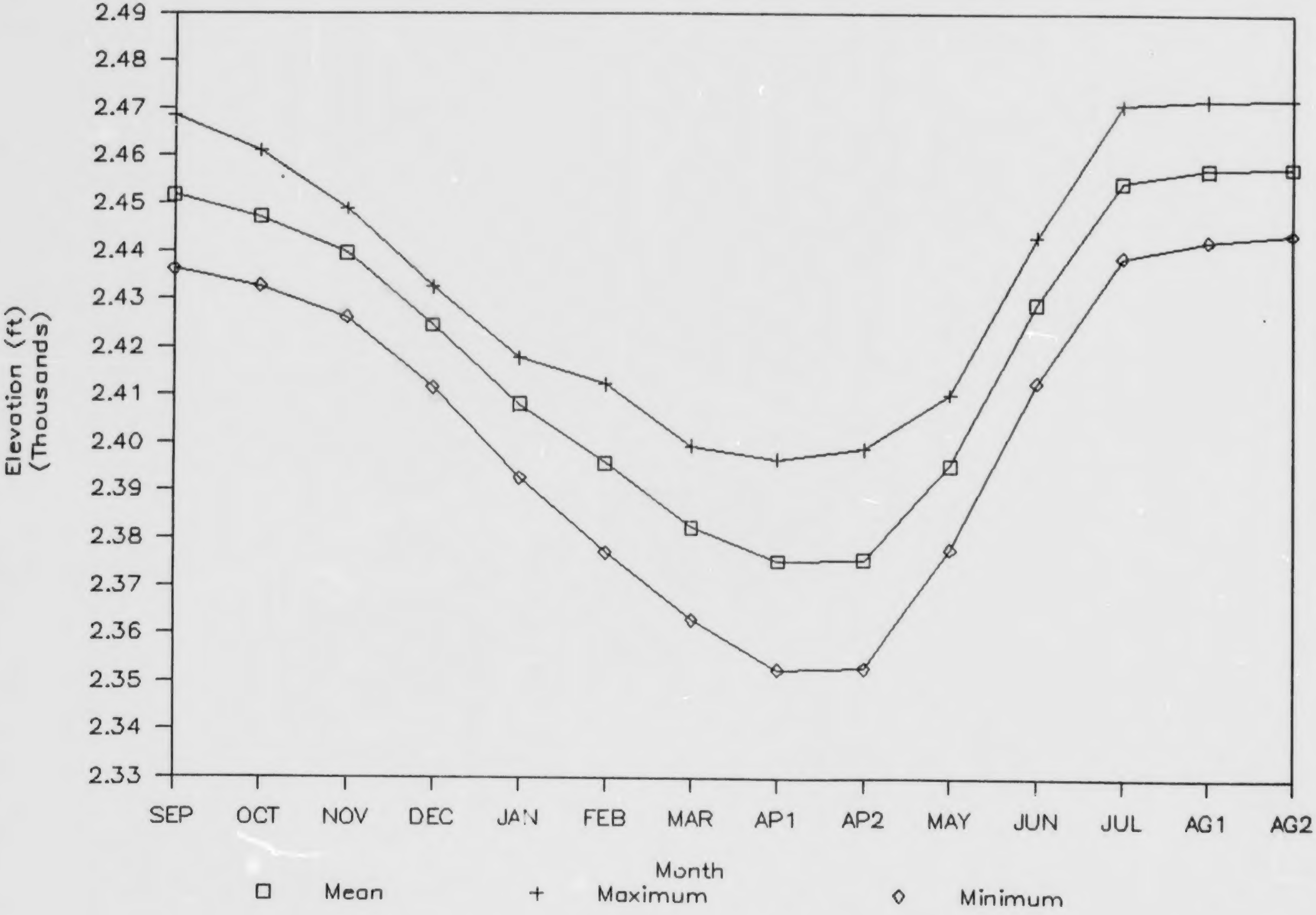


Table A5.2.2 Summary table of median (50% exceedance) outflows, Mica Reservoir, Regime 1 (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	NT	MIN	NT
1989	20518.0	14350.0	17195.0	34000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	10000.0	21633.0	34578.0	33626.0	18541.6	24578.0	34578.0	13	10000.0	9
1990	25806.0	23367.0	25805.0	34000.0	26000.0	22925.0	17000.0	15000.0	10000.0	10000.0	10000.0	24338.0	36359.0	33717.0	22231.6	26359.0	36359.0	13	10000.0	9
1991	30209.0	20359.0	22608.0	32082.0	24614.0	16851.0	20000.0	15000.0	10000.0	10000.0	10000.0	24073.0	36359.0	37409.0	21681.7	27409.0	37409.0	14	10000.0	9
1992	31972.0	21539.0	22798.0	24931.0	22604.0	15590.0	18000.0	18000.0	18000.0	10000.0	10000.0	23082.0	40000.0	33182.0	21258.9	30000.0	40000.0	13	10000.0	10
1993	32026.0	21329.0	21886.0	27238.0	27000.0	23553.0	18983.0	25361.0	10000.0	10000.0	5577.0	20652.0	33910.0	33717.0	21644.8	28333.0	33910.0	13	5577.0	11
1994	32815.0	22185.0	20540.0	27000.0	27000.0	25000.0	21990.0	22000.0	10000.0	10000.0	10000.0	21824.0	34637.0	33687.0	22376.3	24637.0	34637.0	13	10000.0	9
1995	29230.0	18219.0	19313.0	27000.0	27000.0	25000.0	18609.0	22000.0	10000.0	10000.0	8501.0	20317.0	33779.0	32984.0	21047.5	25278.0	33779.0	13	8501.0	11
1996	30649.0	18340.0	20313.0	27000.0	27000.0	25000.0	20252.0	22000.0	10000.0	10000.0	7307.0	21430.0	34118.0	33717.0	21434.0	26811.0	34118.0	13	7307.0	11
1997	29624.0	18340.0	19218.0	27000.0	27000.0	22084.0	20488.0	22000.0	10000.0	10000.0	10000.0	21124.0	34794.0	33717.0	21261.1	24794.0	34794.0	13	10000.0	9
1998	29216.0	16759.0	16750.0	27000.0	27000.0	24602.0	21089.0	22000.0	10000.0	10000.0	8743.0	21800.0	35363.0	33870.0	21131.3	26620.0	35363.0	13	8743.0	11
1999	29849.0	18553.0	15058.0	27000.0	26713.0	23371.0	21238.0	27000.0	10000.0	10000.0	10000.0	23975.0	34461.0	33217.0	21508.0	24461.0	34461.0	13	10000.0	9
2000	31260.0	18869.0	15300.0	22000.0	27000.0	21509.0	20547.0	27000.0	10000.0	10000.0	10000.0	26531.0	36705.0	33870.0	21400.3	26705.0	36705.0	13	10000.0	9
2001	32096.0	19123.0	18102.0	25435.0	27000.0	24742.0	22998.0	24271.0	10000.0	10000.0	10000.0	23037.0	36255.0	33870.0	22060.9	26255.0	36255.0	13	10000.0	9
2002	30900.0	19446.0	18313.0	27000.0	27000.0	24102.0	23000.0	22140.0	10000.0	10000.0	10000.0	22960.0	36167.0	33870.0	21984.1	26167.0	36167.0	13	10000.0	9
2003	30347.0	16050.0	14898.0	22000.0	23404.0	18581.0	18004.0	25361.0	10000.0	10000.0	10000.0	24231.0	35783.0	32957.0	19963.8	25783.0	35783.0	13	10000.0	9
2004	31714.0	18445.0	15707.0	22000.0	27000.0	21577.0	19245.0	27000.0	10000.0	10000.0	10000.0	25800.0	36629.0	35492.0	21337.4	26629.0	36629.0	13	10000.0	9
2005	32236.0	19822.0	18102.0	26057.0	27000.0	25000.0	20049.0	26404.0	10000.0	10000.0	10000.0	25000.0	35550.0	33717.0	22175.1	25550.0	35550.0	13	10000.0	9
2006	32236.0	18832.0	15906.0	24602.0	27000.0	25000.0	19847.0	22847.0	10000.0	10000.0	10000.0	25285.0	36629.0	33717.0	21692.0	26629.0	36629.0	13	10000.0	9
2007	31112.0	18340.0	16252.0	24008.0	27000.0	25000.0	22521.0	27000.0	10000.0	10000.0	9932.0	23616.0	36255.0	33149.0	21748.6	26323.0	36255.0	13	9932.0	11
2008	32036.0	17874.0	16640.0	22000.0	27000.0	23554.0	20286.0	25361.0	10000.0	10000.0	10000.0	25729.0	36359.0	33850.0	21492.0	26359.0	36359.0	13	10000.0	9
AVG	30292.6	19007.1	18535.2	26467.7	26118.6	22160.3	20057.3	22637.3	10400.0	10000.0	9503.0	23321.8	35734.5	33866.8						
RNG	12297.0	9017.0	10907.0	12000.0	5964.0	14835.0	6000.0	12000.0	8000.0	0.0	4423.0	6214.0	6221.0	4452.0						
SDEV	2798.2	2088.9	3008.7	3558.1	1763.1	3970.5	1794.6	4065.6	1788.9	0.0	1163.2	1836.6	1407.2	984.8						
FMAX	32815.0	23367.0	25805.0	34000.0	27000.0	25000.0	23000.0	27000.0	18000.0	10000.0	10000.0	26531.0	40000.0	37409.0						
FMIN	20518.0	14350.0	14898.0	22000.0	21036.0	10165.0	17000.0	15000.0	10000.0	10000.0	5577.0	20317.0	33779.0	32957.0						
MXYR	1994	1990	1990	1989	1993	1994	2002	1999	1992	1989	1989	2000	1992	1991						
MNYR	1989	1989	2003	2000	1989	1989	1989	1989	1989	1989	1993	1995	1995	2003						

Figure A5.2.2 Maximum, mean and minimum median monthly hydrograph of outflows, Mica Reservoir, Regime 1 (ARO)

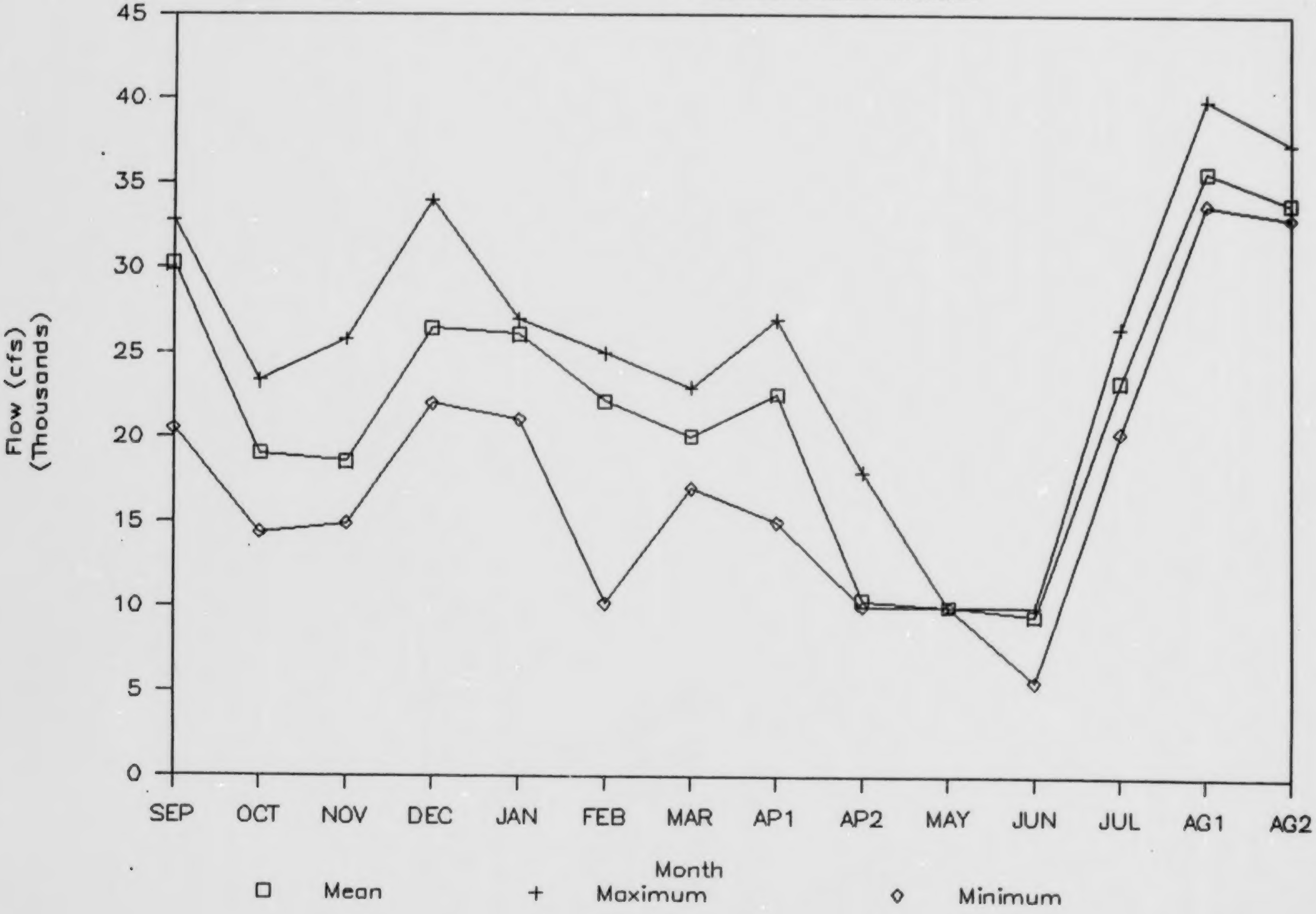


Table A5.2.3 Summary table of median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 1 (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	1444.0	1441.9	1438.1	1433.3	1408.9	1399.2	1399.1	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.3	44.9	1444.0	1	1399.1	7
1990	1443.9	1441.9	1438.8	1432.0	1406.6	1395.2	1394.6	1399.9	1399.9	1414.6	1435.3	1444.0	1444.0	1444.0	1424.2	49.4	1444.0	12	1394.6	7
1991	1443.8	1440.7	1439.0	1433.3	1400.8	1400.2	1398.6	1399.9	1399.9	1415.2	1437.1	1444.0	1444.0	1444.0	1425.4	45.4	1444.0	12	1398.6	7
1992	1443.8	1441.5	1439.6	1432.9	1405.9	1397.2	1396.2	1399.5	1399.9	1415.2	1436.2	1444.0	1444.0	1444.0	1424.7	47.8	1444.0	12	1396.2	7
1993	1443.8	1441.9	1439.4	1435.0	1407.9	1400.1	1398.9	1399.9	1401.4	1415.2	1435.6	1444.0	1444.0	1444.0	1425.5	45.1	1444.0	12	1398.9	7
1994	1443.9	1441.3	1440.0	1436.2	1411.3	1401.6	1399.9	1399.9	1400.1	1415.1	1436.2	1444.0	1444.0	1444.0	1426.1	44.1	1444.0	12	1399.9	7
1995	1443.8	1441.3	1440.2	1436.2	1410.6	1401.6	1398.9	1399.9	1402.1	1414.7	1435.6	1444.0	1444.0	1444.0	1426.0	45.1	1444.0	12	1398.9	7
1996	1443.8	1441.3	1440.2	1436.2	1412.9	1404.4	1399.9	1399.9	1401.6	1414.1	1436.1	1444.0	1444.0	1444.0	1426.5	44.1	1444.0	12	1399.9	7
1997	1443.8	1441.9	1440.5	1436.2	1411.1	1402.9	1399.9	1399.9	1401.0	1414.2	1435.3	1444.0	1444.0	1444.0	1426.2	44.1	1444.0	12	1399.9	7
1998	1443.8	1441.2	1439.3	1435.3	1409.2	1400.1	1399.9	1399.9	1400.6	1415.2	1436.1	1444.0	1444.0	1444.0	1425.7	44.1	1444.0	12	1399.9	7
1999	1443.9	1441.9	1440.1	1435.9	1410.8	1402.1	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	12	1399.9	7
2000	1443.9	1441.9	1441.4	1436.2	1412.8	1404.6	1399.9	1399.9	1403.4	1415.2	1435.3	1444.0	1444.0	1444.0	1426.7	44.1	1444.0	12	1399.9	7
2001	1443.8	1441.7	1440.8	1436.2	1412.3	1404.0	1399.9	1399.9	1401.6	1415.2	1435.6	1444.0	1444.0	1444.0	1426.5	44.1	1444.0	12	1399.9	7
2002	1443.9	1441.5	1440.0	1435.2	1411.2	1402.2	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	12	1399.9	7
2003	1443.9	1441.9	1441.0	1436.2	1412.7	1404.6	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.9	44.1	1444.0	12	1399.9	7
2004	1443.9	1441.9	1441.5	1436.2	1413.6	1404.5	1399.9	1399.9	1401.7	1415.2	1437.3	1444.0	1444.0	1444.0	1426.9	44.1	1444.0	12	1399.9	7
2005	1444.0	1441.9	1441.6	1436.2	1413.3	1405.1	1399.9	1400.1	1403.4	1415.2	1437.5	1444.0	1444.0	1444.0	1427.0	44.1	1444.0	1	1399.9	7
2006	1443.9	1441.9	1441.8	1436.2	1414.1	1407.1	1399.9	1400.7	1403.9	1416.3	1435.4	1444.0	1444.0	1444.0	1427.2	44.1	1444.0	12	1399.9	7
2007	1443.9	1441.9	1441.8	1436.2	1411.6	1402.8	1399.9	1399.9	1403.4	1415.2	1435.6	1444.0	1444.0	1444.0	1426.5	44.1	1444.0	12	1399.9	7
2008	1444.0	1441.9	1442.1	1436.2	1413.8	1404.1	1399.9	1399.9	1402.4	1415.2	1435.6	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	1	1399.9	7
AVG	1443.9	1441.7	1440.4	1435.4	1411.0	1402.2	1399.2	1399.9	1401.8	1415.1	1436.2	1444.0	1444.0	1444.0						
RNG	0.2	1.2	4.0	4.2	8.2	11.9	5.3	1.2	4.0	2.2	2.2	0.0	0.0	0.0						
SDEV	0.1	0.3	1.1	1.4	2.4	2.9	1.4	0.2	1.4	0.4	0.8	0.0	0.0	0.0						
FMAX	1444.0	1441.9	1442.1	1436.2	1414.1	1407.1	1399.9	1400.7	1403.9	1416.3	1437.5	1444.0	1444.0	1444.0						
FMIN	1443.8	1440.7	1438.1	1432.0	1405.9	1395.2	1394.6	1399.5	1399.9	1414.1	1435.3	1444.0	1444.0	1444.0						
MXYR	1989	1989	2008	1994	2006	2006	1994	2006	2006	2006	2005	1989	1989	1989						
MNYR	1991	1991	1989	1990	1992	1990	1990	1992	1989	1996	1990	1989	1989	1989						

Figure A5.2.3 Maximum, mean and minimum median monthly hydrograph of elevations, Arrow Lakes Reservoir, Regime 1 (ARO)

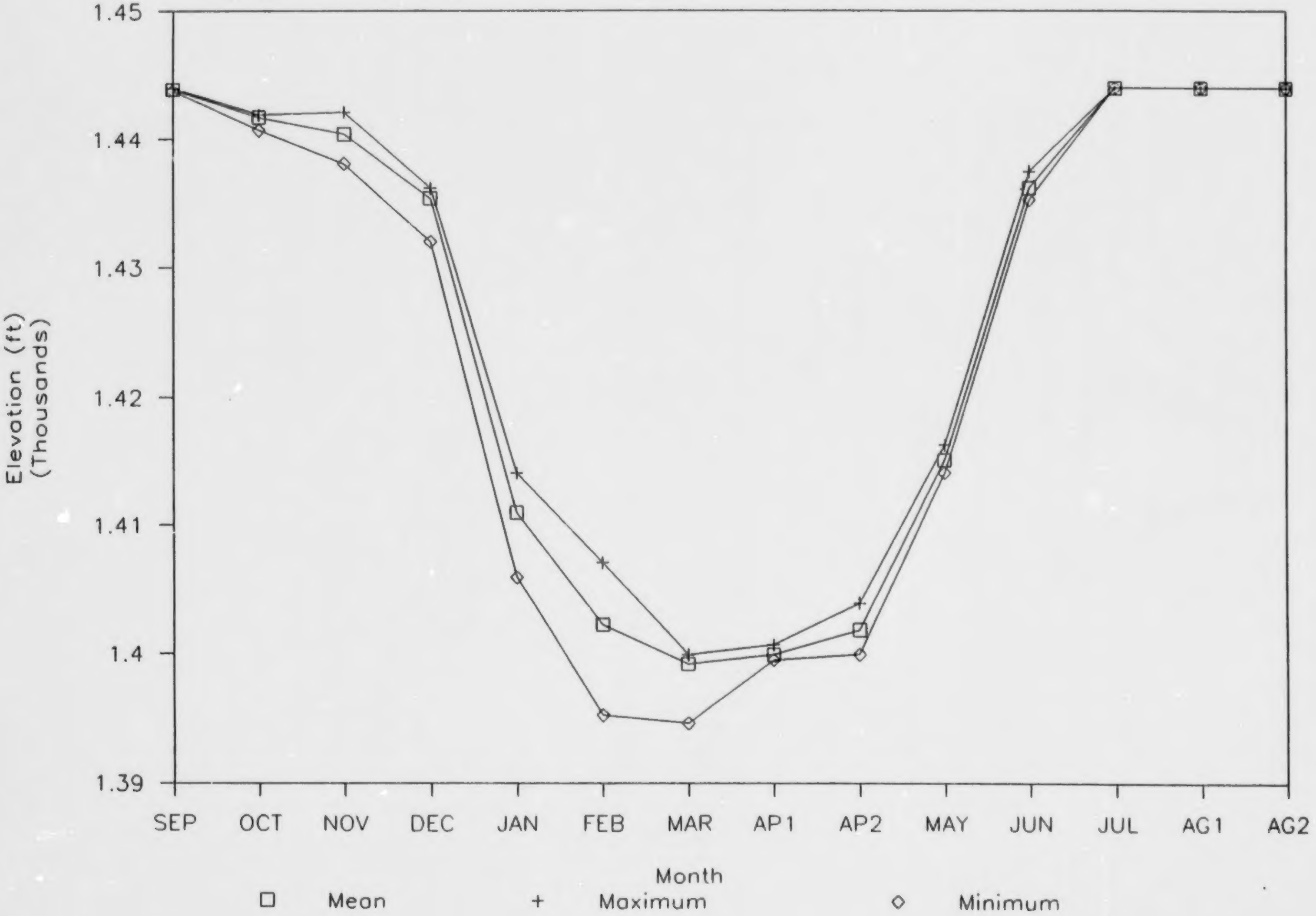
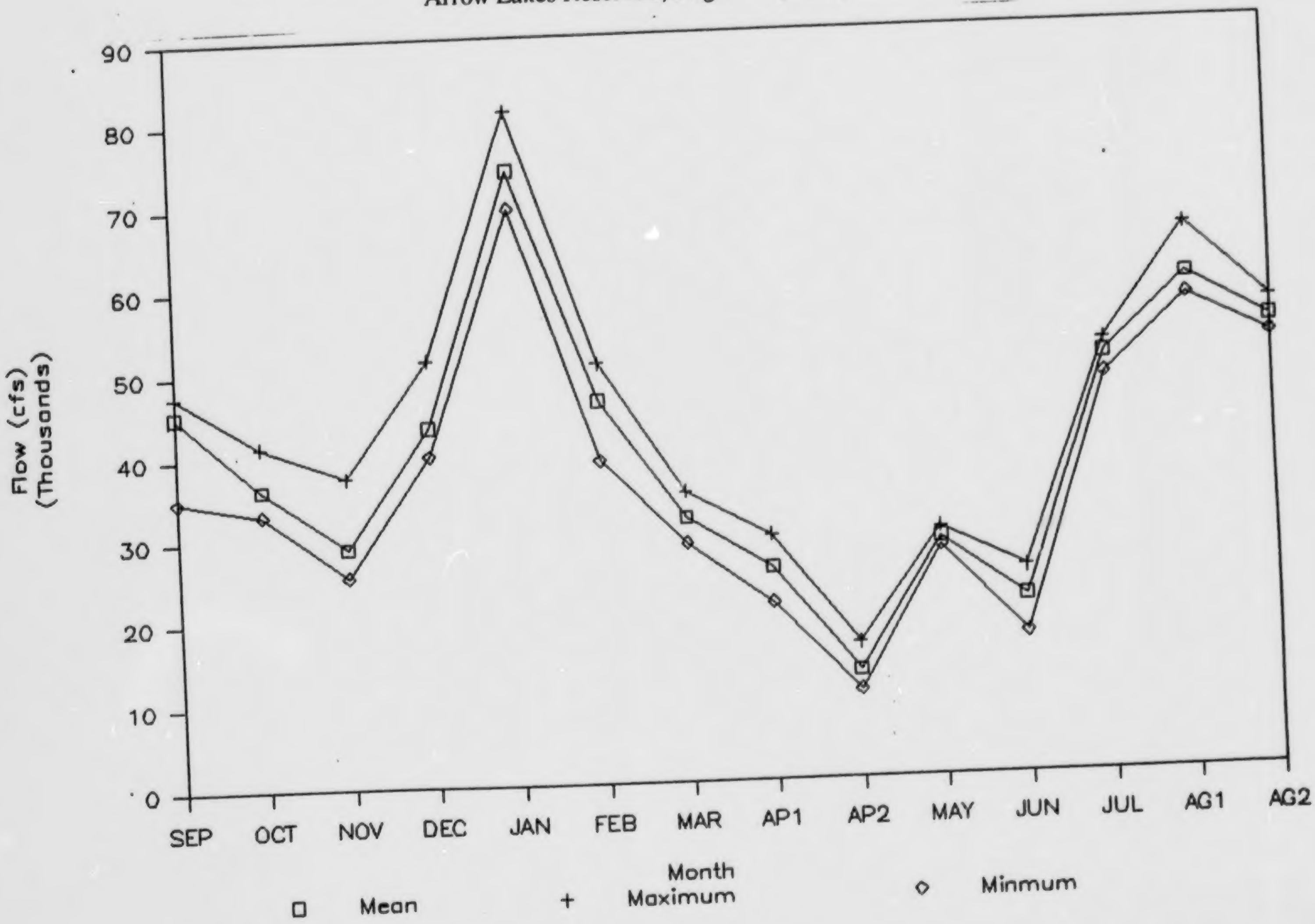


Table A5.2.4 Summary table of median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 1 (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	34978.0	33209.0	32430.0	40815.0	69417.0	38842.0	28559.0	22886.0	12775.0	27982.0	21183.0	47521.0	60493.0	54162.0	38174.5	56642.0	69417.0	5	12775.0	9
1990	41824.0	41497.0	37610.0	51533.0	71041.0	48072.0	29395.0	21470.0	14034.0	28903.0	22306.0	49417.0	61095.0	53148.0	41372.6	57007.0	71041.0	5	14034.0	9
1991	45458.0	38133.0	33083.0	49096.0	72891.0	44272.0	31436.0	21470.0	13282.0	28903.0	21236.0	50931.0	59967.0	56019.0	40900.7	59609.0	72891.0	5	13282.0	9
1992	47343.0	39764.0	33328.0	46632.0	70932.0	44333.0	30308.0	21155.0	16040.0	27744.0	19663.0	48775.0	65172.0	54015.0	40584.4	54892.0	70932.0	5	16040.0	9
1993	46350.0	37873.0	32531.0	45307.0	81090.0	47315.0	31294.0	24424.0	11310.0	27325.0	20986.0	48785.0	58110.0	53810.0	41056.9	69780.0	81090.0	5	11310.0	9
1994	47735.0	38847.0	30416.0	43969.0	77031.0	48362.0	32491.0	25837.0	11954.0	27325.0	18928.0	50560.0	56677.0	52390.0	40757.8	65077.0	77031.0	5	11954.0	9
1995	45162.0	35823.0	28570.0	43847.0	78682.0	45340.0	29803.0	23068.0	10439.0	27413.0	17529.0	49108.0	58218.0	52526.0	39450.2	68243.0	78682.0	5	10439.0	9
1996	45280.0	35088.0	28486.0	42822.0	73916.0	42842.0	34436.0	25758.0	13555.0	27692.0	18678.0	49178.0	56705.0	54089.0	39456.0	60361.0	73916.0	5	13555.0	9
1997	45389.0	35635.0	27758.0	42571.0	74939.0	42391.0	33734.0	25746.0	11947.0	29560.0	16733.0	48742.0	58733.0	53662.0	39374.7	62992.0	74939.0	5	11947.0	9
1998	44941.0	35269.0	28052.0	41734.0	76490.0	46356.0	29299.0	25750.0	12447.0	28903.0	20986.0	48859.0	58778.0	54386.0	39714.1	64043.0	76490.0	5	12447.0	9
1999	44353.0	35362.0	27326.0	41540.0	72362.0	44509.0	31550.0	25751.0	11947.0	28903.0	20822.0	48805.0	58755.0	52940.0	39185.7	60415.0	72362.0	5	11947.0	9
2000	45791.0	35759.0	26081.0	40169.0	72434.0	46152.0	33556.0	29249.0	13505.0	28902.0	24691.0	51338.0	60323.0	54289.0	40296.3	58929.0	72434.0	5	13505.0	9
2001	46856.0	36622.0	28161.0	40855.0	76578.0	47937.0	31826.0	27288.0	13502.0	27453.0	20986.0	49119.0	58755.0	54157.0	40270.3	63076.0	76578.0	5	13502.0	9
2002	46694.0	36185.0	28932.0	42043.0	77430.0	46850.0	30311.0	26662.0	11520.0	29571.0	22306.0	50485.0	58548.0	54178.0	40521.8	65910.0	77430.0	5	11520.0	9
2003	44477.0	33754.0	25604.0	40010.0	72512.0	45593.0	30610.0	25749.0	12421.0	29509.0	20986.0	51410.0	59371.0	51846.0	39096.5	60091.0	72512.0	5	12421.0	9
2004	46240.0	35303.0	26063.0	40802.0	71661.0	47794.0	34718.0	28309.0	13348.0	28807.0	24221.0	51158.0	58755.0	54777.0	40363.5	58313.0	71661.0	5	13348.0	9
2005	47419.0	36253.0	27153.0	41983.0	72738.0	47425.0	30526.0	27903.0	14558.0	27325.0	22306.0	51596.0	57674.0	53543.0	40130.3	58180.0	72738.0	5	14558.0	9
2006	46407.0	34844.0	25896.0	41251.0	69635.0	44609.0	32563.0	26889.0	11374.0	28903.0	24663.0	51195.0	58374.0	53662.0	39593.0	58261.0	69635.0	5	11374.0	9
2007	46536.0	35025.0	27087.0	42255.0	75305.0	50199.0	32731.0	24450.0	12573.0	27801.0	22076.0	51338.0	59573.0	53662.0	40456.8	62732.0	75305.0	5	12573.0	9
2008	46412.0	34767.0	25589.0	41763.0	71508.0	50548.0	33003.0	27806.0	13504.0	28656.0	20986.0	51486.0	60168.0	53847.0	40198.4	58004.0	71508.0	5	13504.0	9
AVG	45282.3	36250.6	29007.8	43449.9	73929.6	45987.1	31607.4	25381.0	12801.8	28379.0	21113.6	49990.3	59212.2	53755.4						
RNG	12757.0	8288.0	12021.0	11523.0	11673.0	11706.0	6159.0	8094.0	5601.0	2246.0	7958.0	4075.0	8495.0	4173.0						
SDEV	2767.8	2037.8	3237.9	3222.8	3150.3	2758.2	1767.9	2362.3	1290.8	810.8	2118.6	1267.6	1821.6	908.2						
FMAX	47735.0	41497.0	37610.0	51533.0	81090.0	50548.0	34718.0	29249.0	16040.0	29571.0	24691.0	51596.0	65172.0	56019.0						
FMIN	34978.0	33209.0	25589.0	40010.0	69417.0	38842.0	28559.0	21155.0	10439.0	27325.0	16733.0	47521.0	56677.0	51846.0						
MXYR	1994	1990	1990	1990	1993	2008	2004	2000	1992	2002	2000	2005	1992	1991						
MNYR	1989	1989	2008	2003	1989	1989	1989	1992	1995	1993	1997	1989	1994	2003						

Figure A5.2.4 Maximum, mean and minimum median monthly hydrograph of outflows, Arrow Lakes Reservoir, Regime 1 (ARO)



APPENDIX 5.3

Differences
Regime 1 (ARO) Compared to Base Case (ARO)

Table A5.3.1 Summary table of differences between median (50% exceedance) elevations, Mica Reservoir, Regime 1 (ARO) - Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	-4.1	-9.3	-10.8	-13.3	-10.3	-8.7	-7.3	-9.2	-9.4	-2.9	-4.2	-4.3	-3.7	-7.1	13.3	0.0	1	-13.3	5
1991	-4.8	-5.1	-8.8	-12.7	-15.3	-14.3	-13.8	-13.8	-12.5	-13.2	-6.3	-6.7	-7.1	-6.1	-10.1	10.5	-4.8	1	-15.3	5
1992	-6.7	-4.4	-9.4	-13.4	-18.9	-19.6	-23.8	-23.9	-24.6	-18.5	-14.3	-14.1	-11.6	-11.9	-14.9	20.2	-4.4	2	-24.6	9
1993	-10.7	-9.6	-12.5	-16.8	-19.3	-24.9	-26.9	-28.5	-28.8	-22.8	-18.2	-16.4	-17.6	-19.5	-18.8	19.2	-9.6	2	-28.8	9
1994	-26.6	-30.5	-32.0	-34.8	-36.7	-40.9	-47.1	-48.9	-49.3	-37.2	-32.9	-31.1	-31.5	-31.5	-35.9	22.7	-26.6	1	-49.3	9
1995	-37.1	-40.5	-42.3	-44.0	-47.9	-50.5	-49.1	-51.9	-51.9	-41.5	-31.8	-28.6	-29.8	-31.1	-41.3	23.3	-28.6	12	-51.9	8
1996	-38.9	-40.1	-41.8	-42.1	-43.2	-44.7	-50.0	-50.6	-49.2	-39.1	-33.3	-28.9	-27.4	-28.9	-40.0	23.2	-27.4	13	-50.6	8
1997	-36.2	-37.0	-39.2	-39.1	-37.7	-38.5	-44.9	-45.7	-45.2	-35.4	-29.2	-23.9	-23.5	-23.5	-35.8	22.2	-23.5	13	-45.7	8
1998	-28.1	-29.8	-32.9	-30.8	-34.0	-34.5	-33.3	-31.6	-31.2	-25.2	-18.1	-14.6	-15.2	-16.6	-27.4	19.9	-14.6	12	-34.5	6
1999	-20.3	-23.4	-26.0	-25.4	-28.6	-28.2	-26.5	-27.8	-25.2	-19.9	-13.7	-12.3	-13.0	-13.1	-22.0	16.3	-12.3	12	-28.6	5
2000	-18.3	-21.7	-25.0	-24.3	-26.0	-23.5	-21.6	-21.9	-22.4	-16.7	-12.0	-5.8	-7.5	-8.8	-18.8	20.2	-5.8	12	-26.0	5
2001	-15.7	-19.3	-24.4	-24.1	-29.9	-30.8	-30.2	-29.7	-29.1	-23.5	-17.6	-14.0	-15.3	-16.7	-22.9	16.8	-14.0	12	-30.8	6
2002	-22.5	-27.6	-31.4	-30.5	-34.1	-38.6	-37.3	-38.8	-35.9	-28.9	-25.0	-20.8	-22.0	-23.2	-29.7	18.0	-20.8	12	-38.8	8
2003	-27.8	-31.0	-33.9	-32.1	-32.0	-32.0	-28.4	-27.8	-25.9	-21.1	-15.4	-13.5	-14.6	-15.6	-25.8	20.4	-13.5	12	-33.9	3
2004	-21.7	-23.6	-25.9	-27.1	-30.3	-29.4	-24.6	-23.7	-23.0	-18.8	-12.6	-9.0	-10.8	-12.5	-21.5	21.3	-9.0	12	-30.3	5
2005	-18.9	-22.0	-25.6	-28.2	-32.3	-33.6	-32.0	-31.9	-30.2	-22.0	-17.4	-14.5	-15.7	-16.0	-24.5	19.1	-14.5	12	-33.6	6
2006	-24.4	-28.2	-30.6	-35.0	-37.3	-38.0	-37.2	-38.3	-35.6	-30.2	-23.8	-17.5	-18.6	-21.4	-29.9	20.8	-17.5	12	-38.3	8
2007	-26.2	-28.6	-32.0	-33.4	-35.5	-37.6	-35.8	-36.6	-36.7	-28.7	-22.4	-18.4	-18.8	-19.9	-29.6	19.2	-18.4	12	-37.6	6
2008	-26.7	-29.3	-32.0	-36.3	-36.6	-35.7	-31.0	-32.2	-33.1	-26.2	-21.8	-14.6	-14.6	-15.3	-28.1	22.0	-14.6	12	-36.6	5
AVG	-20.6	-22.8	-25.8	-27.0	-29.4	-30.3	-30.1	-30.5	-30.0	-23.9	-18.4	-15.4	-15.9	-16.8						
RNG	38.9	40.5	42.3	44.0	47.9	50.5	50.0	51.9	51.9	41.5	33.3	31.1	31.5	31.5						
SDEV	11.5	12.2	11.9	11.4	11.3	12.2	13.0	13.6	13.4	10.2	9.4	8.3	8.2	8.5						
FMAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
FMIN	-38.9	-40.5	-42.3	-44.0	-47.9	-50.5	-50.0	-51.9	-51.9	-41.5	-33.3	-31.1	-31.5	-31.5						
MXYR	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989						
MNYR	1996	1995	1995	1995	1995	1995	1996	1995	1995	1995	1996	1994	1994	1994						

Figure A5.3.1 Maximum, mean and minimum differences between median monthly hydrographs of elevations, Mica Reservoir, Regime 1 (ARO) - Base Case (ARO)

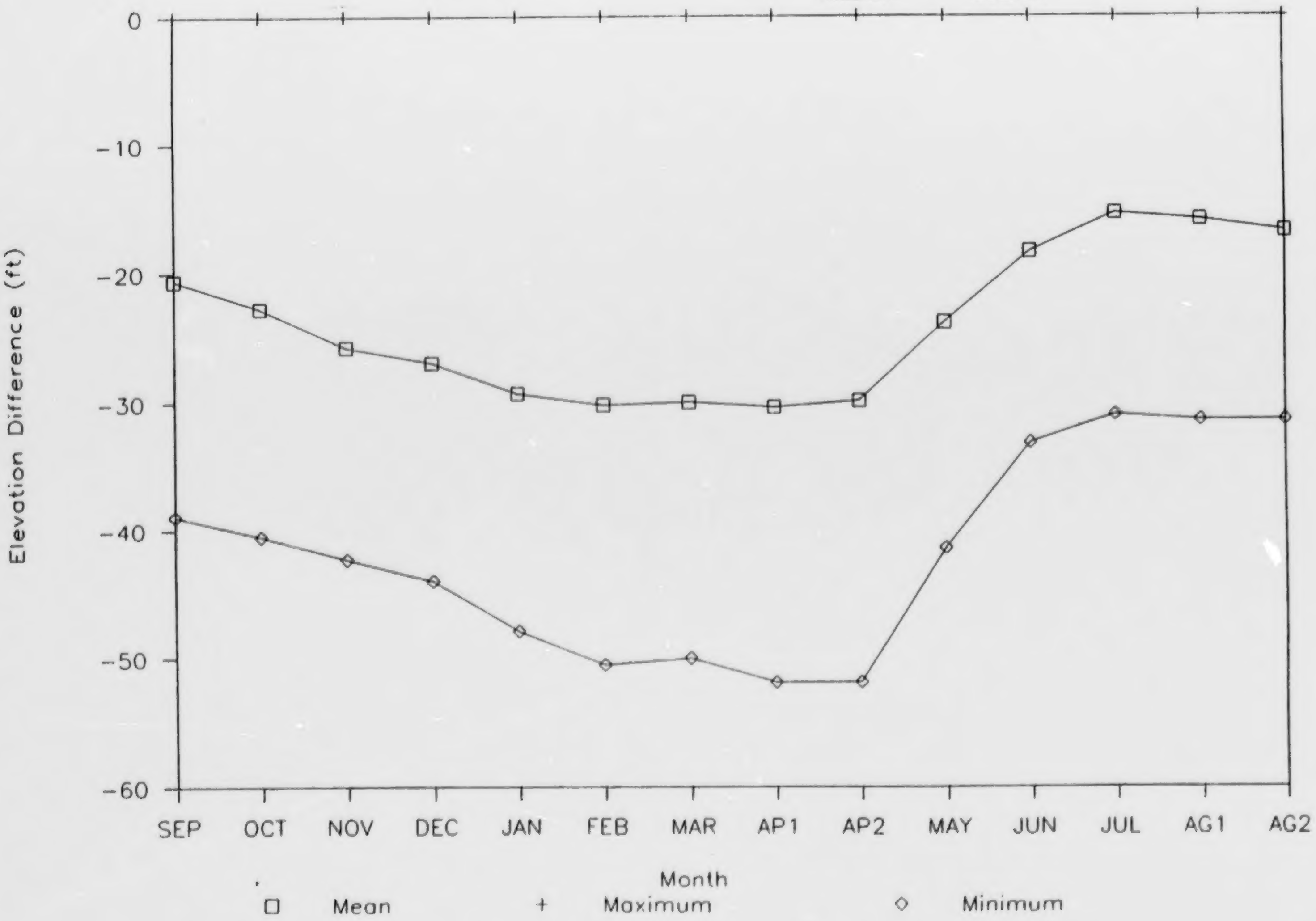


Table A5.3.2 Summary table of differences between median (50% exceedance) outflows, Mica Reservoir, Regime 1 (ARO) - Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	6953.0	6339.0	5967.0	0.0	910.0	0.0	0.0	0.0	0.0	0.0	-1966.0	-48.0	0.0	1514.9	8919.0	6953.0	2	-1966.0	12
1991	3209.0	3275.0	3499.0	4578.0	-1731.0	-5683.0	0.0	0.0	0.0	0.0	0.0	-1922.0	-57.0	-370.0	417.6	10261.0	4578.0	4	-5683.0	6
1992	2005.0	3027.0	3766.0	1931.0	915.0	-2766.0	0.0	0.0	0.0	0.0	0.0	-4232.0	-639.0	-925.0	322.0	7998.0	3766.0	3	-4232.0	12
1993	1637.0	2179.0	4152.0	238.0	0.0	-1447.0	-4017.0	-1516.0	0.0	0.0	-4423.0	-3323.0	1334.0	1680.0	-354.6	8575.0	4152.0	3	-4423.0	11
1994	11717.0	7435.0	5482.0	0.0	0.0	0.0	-1010.0	-4590.0	0.0	0.0	0.0	-4883.0	2061.0	1650.0	1525.1	16600.0	11717.0	1	-4883.0	12
1995	8392.0	3469.0	4415.0	0.0	0.0	0.0	-4391.0	-5000.0	0.0	0.0	-1499.0	-3914.0	963.0	947.0	410.6	13392.0	8392.0	1	-5000.0	8
1996	9811.0	3260.0	5415.0	0.0	0.0	0.0	-2748.0	-5000.0	0.0	0.0	-2693.0	-6588.0	1112.0	1448.0	436.4	16399.0	9811.0	1	-6588.0	12
1997	8586.0	2920.0	4941.0	0.0	0.0	-2916.0	-2512.0	-5000.0	0.0	0.0	0.0	-4904.0	1798.0	1680.0	446.2	13586.0	8586.0	1	-5000.0	8
1998	8178.0	1679.0	1852.0	0.0	0.0	-398.0	-1911.0	-5000.0	0.0	0.0	-1257.0	-7050.0	2367.0	1833.0	57.8	15228.0	8178.0	1	-7050.0	12
1999	8811.0	3243.0	860.0	0.0	-287.0	-1629.0	-1762.0	0.0	0.0	0.0	0.0	-3025.0	1465.0	760.0	610.3	11836.0	8811.0	1	-3025.0	12
2000	10742.0	3789.0	1102.0	0.0	0.0	-3491.0	-2453.0	0.0	0.0	0.0	0.0	-4346.0	3699.0	1413.0	658.3	15088.0	10742.0	1	-4346.0	12
2001	10858.0	4373.0	3904.0	-1565.0	0.0	-258.0	-2.0	-2729.0	0.0	0.0	0.0	-3963.0	3259.0	1833.0	1210.7	14821.0	10858.0	1	-3963.0	12
2002	9862.0	4366.0	4115.0	0.0	0.0	-898.0	0.0	-4860.0	0.0	0.0	0.0	-5917.0	3171.0	1833.0	966.7	15779.0	9862.0	1	-5917.0	12
2003	9309.0	1300.0	909.0	-5000.0	-3596.0	-6419.0	-4996.0	-1639.0	0.0	0.0	0.0	-2769.0	2777.0	920.0	-852.8	15728.0	9309.0	1	-6419.0	6
2004	11196.0	3365.0	1718.0	0.0	0.0	-3423.0	-3755.0	0.0	0.0	0.0	0.0	-4877.0	3623.0	2932.0	625.1	16073.0	11196.0	1	-4877.0	12
2005	11198.0	5072.0	4113.0	4057.0	0.0	0.0	-2951.0	-596.0	0.0	0.0	0.0	-3975.0	2554.0	1260.0	1593.6	15173.0	11198.0	1	-3975.0	12
2006	11198.0	4082.0	2663.0	2602.0	0.0	0.0	-3153.0	-4153.0	0.0	0.0	0.0	-4888.0	3223.0	1157.0	1051.5	16086.0	11198.0	1	-4888.0	12
2007	10014.0	3190.0	2054.0	2008.0	0.0	0.0	-479.0	0.0	0.0	0.0	-68.0	-5359.0	3259.0	880.0	1119.1	15373.0	10014.0	1	-5359.0	12
2008	10998.0	2794.0	2442.0	0.0	0.0	-1446.0	-2714.0	-1639.0	0.0	0.0	0.0	-5147.0	2953.0	1323.0	687.1	16145.0	10998.0	1	-5147.0	12
AVG	7886.0	3488.6	3187.1	740.8	-234.9	-1493.2	-1942.7	-2086.1	0.0	0.0	-497.0	-4152.4	1943.7	1112.7						
RNG	11717.0	7435.0	6339.0	10967.0	4511.0	7329.0	4996.0	5000.0	0.0	0.0	4423.0	7050.0	4338.0	3857.0						
SDEV	4039.2	1706.2	1769.8	2340.5	910.3	2021.8	1668.5	2180.9	0.0	0.0	1163.2	1671.6	1366.4	892.6						
FMAX	11717.0	7435.0	6339.0	5967.0	915.0	910.0	0.0	0.0	0.0	0.0	0.0	0.0	3699.0	2932.0						
FMIN	0.0	0.0	0.0	-5000.0	-3596.0	-6419.0	-4996.0	-5000.0	0.0	0.0	-4423.0	-7050.0	-639.0	-925.0						
MXYR	1994	1994	1990	1990	1992	1990	1989	1989	1989	1989	1989	1989	2000	2004						
MNYR	1989	1989	1989	2003	2003	2003	2003	1995	1989	1989	1993	1998	1992	1992						

Figure A5.3.2 Maximum, mean and minimum differences between median monthly hydrographs for outflows, Mica Reservoir, Regime 1 (ARO) - Base Case (ARO)

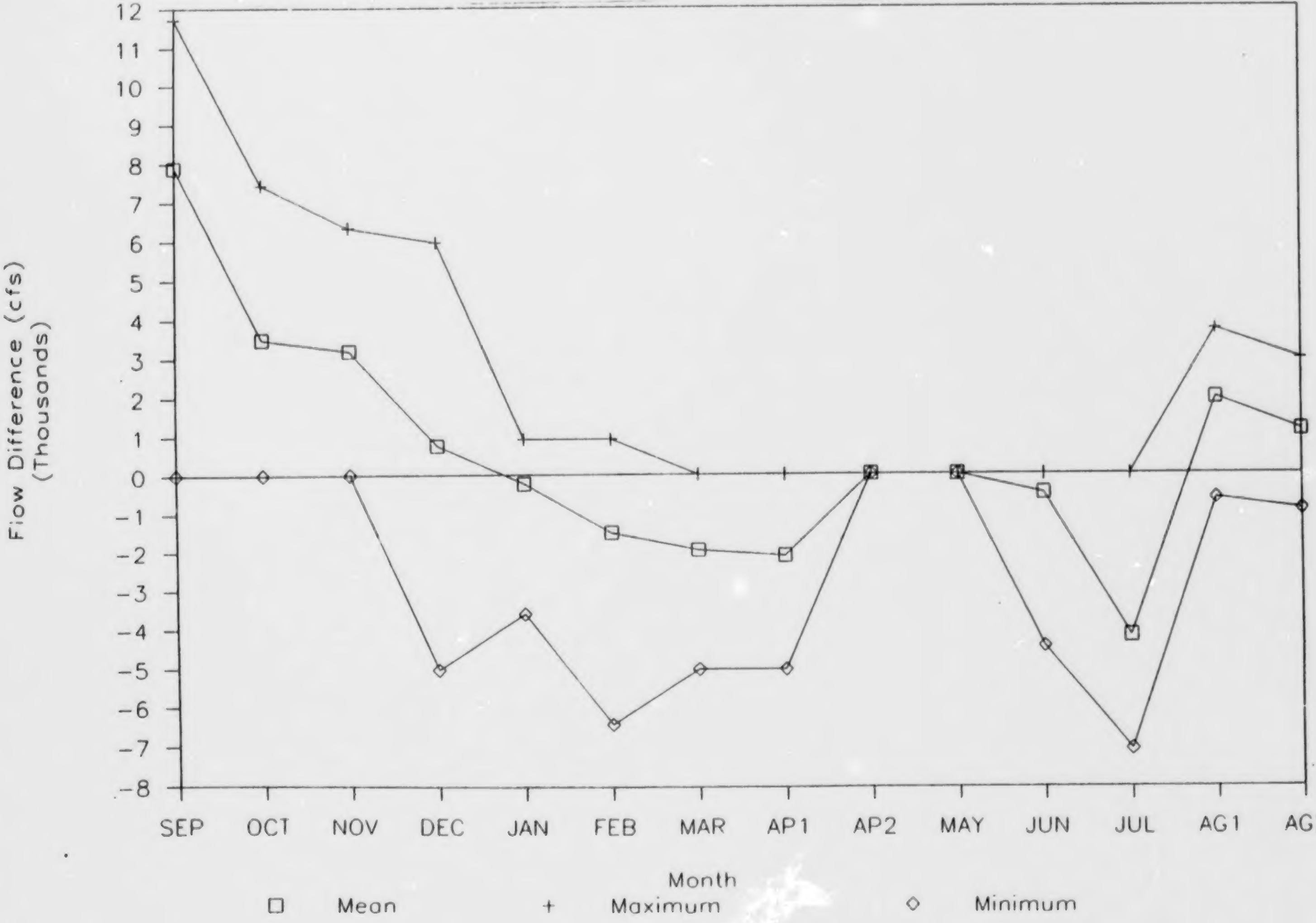


Table A5.3.3 Summary table of differences between median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 1 (ARO) - Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	0.1	0.0	0.1	0.3	-1.3	-1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	1.9	0.3	5	-1.6	7
1991	0.0	0.0	0.0	0.1	-0.4	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.5	0.1	4	-0.4	5
1992	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	-0.8	0.0	0.0	0.0	-0.1	0.9	0.1	4	-0.8	11
1993	0.0	0.1	0.2	0.2	0.0	0.5	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.5	0.5	6	0.0	1
1994	0.2	0.8	0.3	0.0	0.4	0.7	0.0	0.0	0.2	0.5	0.4	0.0	0.0	0.0	0.3	0.8	0.8	2	0.0	4
1995	0.3	0.9	0.2	0.0	0.9	1.5	0.2	0.0	1.5	0.1	0.0	0.0	0.0	0.0	0.4	1.5	1.5	6	0.0	4
1996	0.2	0.6	-0.2	0.0	0.6	0.4	0.0	0.0	1.7	1.1	0.0	0.0	0.0	0.0	0.3	1.9	1.7	9	-0.2	3
1997	0.1	0.5	0.1	0.0	0.1	0.4	0.0	0.0	0.1	1.0	-0.3	0.0	0.0	0.0	0.2	1.3	1.0	10	-0.3	11
1998	0.1	0.4	-0.1	0.0	-0.1	-0.2	0.3	0.0	0.7	0.0	0.5	0.0	0.0	0.0	0.1	0.9	0.7	9	-0.2	6
1999	0.1	0.2	0.2	0.5	0.6	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.6	5	0.0	7
2000	0.1	0.0	-0.1	0.0	-0.2	0.9	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.1	1.7	1.5	9	-0.2	5
2001	0.1	0.4	-0.2	0.0	0.0	0.6	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.1	0.8	0.6	6	-0.2	3
2002	0.1	0.2	0.1	0.2	0.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.4	1.4	6	0.0	7
2003	0.1	0.3	0.3	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	2	0.0	4
2004	0.1	0.0	-0.1	0.0	0.3	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.4	9	-0.1	3
2005	0.2	0.3	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.3	0.3	2	0.0	3
2006	0.1	0.0	0.1	0.0	0.3	0.4	0.0	0.8	0.0	1.0	-0.2	0.0	0.0	0.0	0.2	1.2	1.0	10	-0.2	11
2007	0.1	0.0	0.1	0.0	0.5	0.5	0.0	0.0	0.0	0.0	-0.5	0.0	0.0	0.0	0.1	1.0	0.5	5	-0.5	11
2008	0.1	0.1	0.0	0.0	0.2	0.5	0.5	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.2	0.9	0.9	9	0.0	3
AVG	0.1	0.2	0.0	0.1	0.2	0.3	0.0	0.1	0.4	0.2	0.0	0.0	0.0	0.0						
RNG	0.3	0.9	0.5	0.5	1.3	2.8	2.1	0.8	1.7	1.1	1.3	0.0	0.0	0.0						
SDEV	0.1	0.3	0.1	0.1	0.3	0.6	0.4	0.2	0.6	0.4	0.3	0.0	0.0	0.0						
FMAX	0.3	0.9	0.3	0.5	0.9	1.5	0.5	0.8	1.7	1.1	0.5	0.0	0.0	0.0						
FMIN	0.0	0.0	-0.2	0.0	-0.4	-1.3	-1.6	0.0	0.0	0.0	-0.8	0.0	0.0	0.0						
MXYR	1995	1995	1994	1999	1995	1995	2008	2006	1996	1996	1998	1989	1989	1989						
MNYR	1989	1989	1996	1989	1991	1990	1990	1989	1989	1989	1992	1989	1989	1989						

Figure A5.3.3 Maximum, mean and minimum differences between median monthly hydrographs of elevations, Arrow Lakes Reservoir, Regime 1 (ARO) - Base Case (ARO)

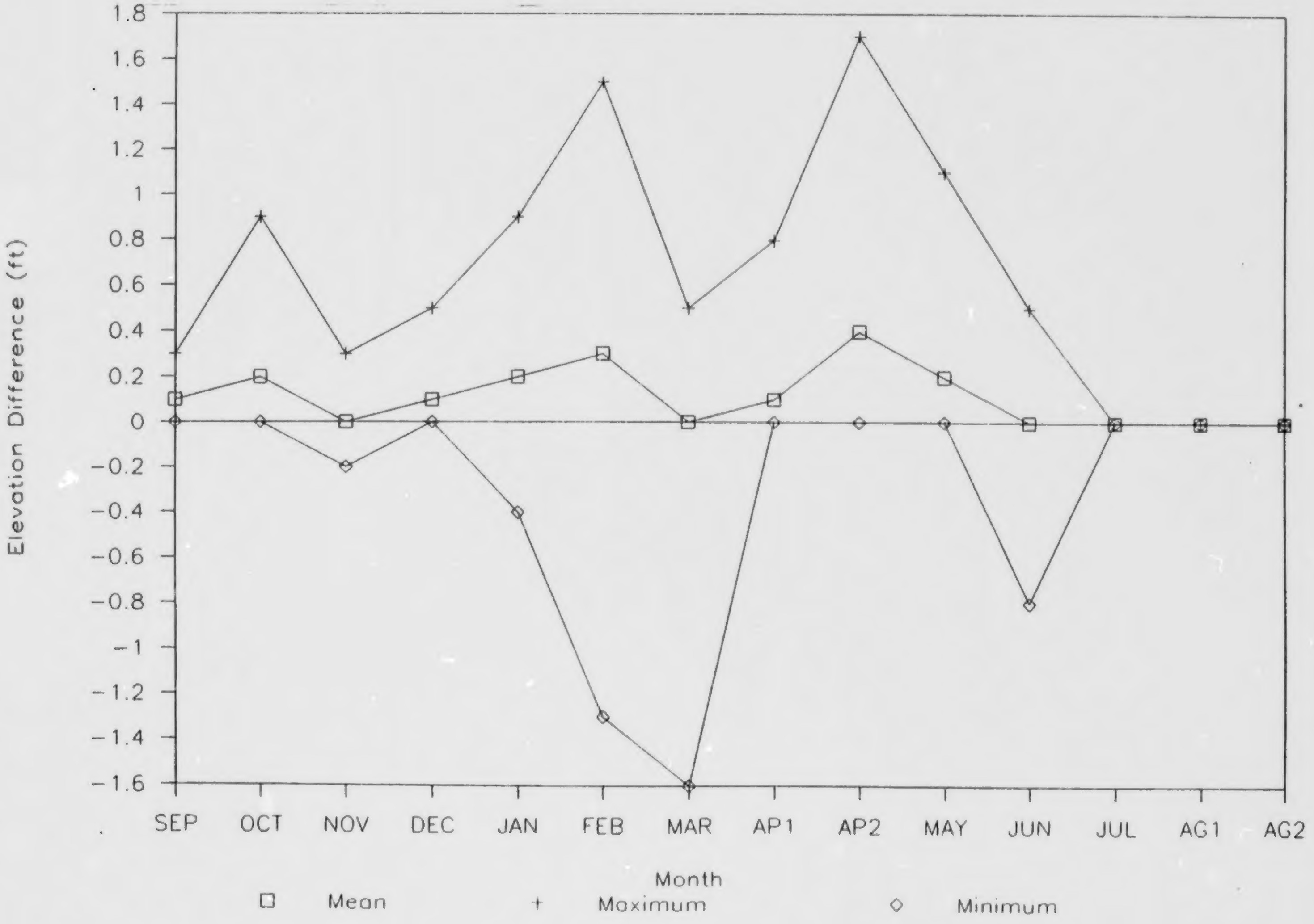
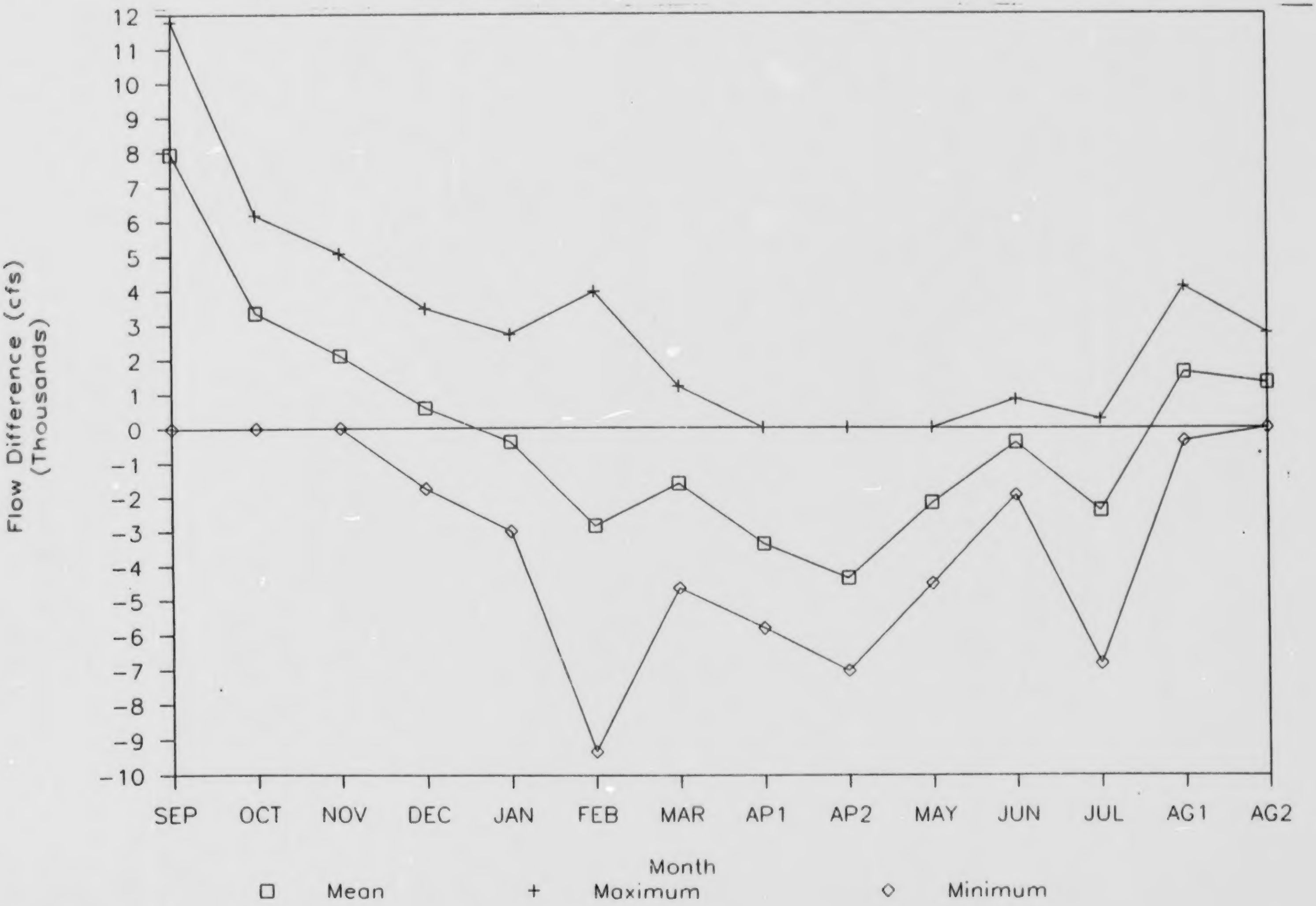


Table A5.3.4 Summary table of differences between median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 1 (ARO) - Base Case (ARO)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	6185.0	5073.0	3472.0	-162.0	3957.0	691.0	0.0	-2659.0	0.0	0.0	-1963.0	-379.0	0.0	1311.2	8844.0	6185.0	2	-2659.0	9
1991	2657.0	2821.0	2272.0	2569.0	-552.0	-745.0	261.0	-1016.0	-1684.0	0.0	-871.0	-2748.0	647.0	140.0	392.3	5569.0	2821.0	2	-2748.0	12
1992	1668.0	2989.0	3220.0	2260.0	1592.0	2033.0	-402.0	-3315.0	-1757.0	-1159.0	-1158.0	-2220.0	0.0	200.0	532.3	6535.0	3220.0	3	-3315.0	8
1993	696.0	924.0	3058.0	2582.0	1804.0	3248.0	303.0	-2657.0	-1796.0	-2248.0	-1166.0	-2372.0	3651.0	1151.0	583.6	6308.0	3651.0	13	-2657.0	8
1994	10726.0	5570.0	3740.0	2174.0	2711.0	879.0	108.0	-3576.0	-4845.0	-2986.0	762.0	-754.0	2048.0	1108.0	1691.5	15571.0	10726.0	1	-4845.0	9
1995	8700.0	3026.0	2147.0	1797.0	-976.0	-2701.0	-2471.0	-5528.0	-7034.0	-3006.0	-1947.0	-1687.0	1541.0	730.0	-188.6	15734.0	8700.0	1	-7034.0	9
1996	9056.0	2507.0	2333.0	1059.0	2612.0	-8879.0	-282.0	-5150.0	-5932.0	-4504.0	-798.0	-6793.0	2076.0	2191.0	-591.4	17935.0	9056.0	1	-8879.0	6
1997	9104.0	2308.0	1167.0	511.0	-1032.0	-9330.0	1192.0	-3530.0	-5899.0	-2776.0	-1433.0	-2415.0	137.0	792.0	-579.5	18434.0	9104.0	1	-9330.0	6
1998	8901.0	2585.0	661.0	-738.0	-1813.0	-5365.0	-3111.0	-3736.0	-5399.0	-3520.0	-1320.0	-1936.0	1674.0	2744.0	-667.9	14300.0	8901.0	1	-5399.0	9
1999	8199.0	3455.0	1216.0	-715.0	-2613.0	-7048.0	-3168.0	-3735.0	-5400.0	-2243.0	833.0	-2352.0	263.0	1298.0	-685.3	15247.0	8199.0	1	-7048.0	6
2000	11036.0	4045.0	761.0	-1565.0	-2199.0	-6377.0	-2417.0	-3621.0	-4341.0	-2211.0	551.0	-4633.0	1635.0	810.0	-480.6	17413.0	11036.0	1	-6377.0	6
2001	11791.0	5024.0	2261.0	-863.0	104.0	-3784.0	-2906.0	-4499.0	-4375.0	-2326.0	-39.0	-2038.0	3584.0	2705.0	494.3	16290.0	11791.0	1	-4499.0	8
2002	10282.0	3903.0	2058.0	-591.0	1291.0	309.0	-2131.0	-2824.0	-5827.0	-925.0	-223.0	-2169.0	4089.0	2536.0	899.3	16109.0	10282.0	1	-5827.0	9
2003	9753.0	2366.0	1082.0	-1753.0	-2379.0	-6277.0	-4652.0	-3737.0	-4926.0	-3329.0	-1320.0	-11.0	1150.0	268.0	-845.2	16030.0	9753.0	1	-6277.0	6
2004	11353.0	3760.0	2198.0	-599.0	-1300.0	-3927.0	-2370.0	-4389.0	-4529.0	-1127.0	703.0	-4813.0	3416.0	1907.0	173.4	16166.0	11353.0	1	-4813.0	12
2005	11661.0	5053.0	2959.0	722.0	-1028.0	-4296.0	-4192.0	-3381.0	-4542.0	-3078.0	226.0	258.0	3215.0	1901.0	573.5	16203.0	11661.0	1	-4542.0	9
2006	11599.0	3702.0	2593.0	415.0	876.0	-5185.0	-2547.0	-5809.0	-6503.0	-3247.0	-103.0	-143.0	2022.0	2020.0	318.8	18102.0	11599.0	1	-6503.0	9
2007	10416.0	3499.0	1979.0	449.0	-2986.0	-1522.0	-1782.0	-5036.0	-5273.0	-2839.0	-453.0	-4511.0	890.0	2380.0	-105.8	15689.0	10416.0	1	-5273.0	9
2008	11292.0	3403.0	1449.0	327.0	-2051.0	-1981.0	-2552.0	-1680.0	-4373.0	-1949.0	-775.0	-4363.0	365.0	1157.0	44.5	15665.0	11292.0	1	-4373.0	9
AVG	7944.5	3356.3	2111.4	575.7	-405.0	-2849.6	-1621.4	-3360.9	-4354.7	-2173.6	-426.5	-2383.1	1601.2	1301.9						
RNG	11791.0	6185.0	5073.0	5225.0	5697.0	13287.0	5844.0	5809.0	7034.0	4504.0	2780.0	7051.0	4468.0	2744.0						
SDEV	4274.6	1464.6	1174.3	1489.8	1746.5	3855.2	1707.4	1643.4	1846.2	1270.1	820.1	1863.8	1394.8	937.5						
FMAX	11791.0	6185.0	5073.0	3472.0	2711.0	3957.0	1192.0	0.0	0.0	0.0	833.0	258.0	4089.0	2744.0						
FMIN	0.0	0.0	0.0	-1753.0	-2986.0	-9330.0	-4652.0	-5809.0	-7034.0	-4504.0	-1947.0	-6793.0	-379.0	0.0						
MXYR	2001	1990	1990	1990	1994	1990	1997	1989	1989	1989	1999	2005	2002	1998						
MNYR	1989	1989	1989	2003	2007	1997	2003	2006	1995	1996	1995	1996	1990	1989						

Figure A5.3.4 Maximum, mean and minimum differences between median monthly hydrographs for outflows, Arrow Lakes Reservoir, Regime 1 (ARO) - Base Case (ARO)



APPENDIX 6

Alternate Operating Scenario (AOS) Summary Tables and Hydrographs

6.1 Base Case (AOS)
6.2 Regime 1 (AOS)
6.3 Differences: Regime 1 (AOS) Compared to Base Case (AOS)

APPENDIX 6.1

Base Case (AOS)

Table A6.1.1 Summary table of median (50% exceedance) elevations, Mica Reservoir, Base Case (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	2455.6	2453.6	2447.5	2428.5	2412.7	2407.9	2395.1	2391.5	2391.2	2407.3	2438.1	2467.4	2468.1	2467.8	2431.1	76.9	2468.1	13	2391.2	9
1990	2464.6	2458.2	2450.9	2436.7	2425.1	2420.6	2408.1	2402.7	2402.8	2418.6	2444.4	2470.8	2471.6	2471.5	2439.4	68.9	2471.6	13	2402.7	8
1991	2464.8	2456.2	2448.8	2435.6	2423.0	2417.0	2403.7	2397.9	2398.8	2413.0	2442.8	2469.8	2470.4	2469.4	2436.9	72.5	2470.4	13	2397.9	8
1992	2462.7	2455.5	2447.5	2436.1	2425.0	2415.3	2405.0	2401.8	2400.3	2414.5	2444.7	2468.6	2469.5	2470.1	2437.1	69.8	2470.1	14	2400.3	9
1993	2463.2	2455.5	2450.0	2435.9	2421.1	2408.4	2395.3	2388.7	2388.8	2407.1	2438.2	2462.7	2466.5	2468.0	2432.8	79.3	2468.0	14	2388.7	8
1994	2468.0	2467.4	2461.9	2448.6	2433.8	2422.5	2409.3	2402.7	2402.7	2416.6	2444.4	2469.8	2473.6	2475.0	2443.3	72.3	2475.0	14	2402.7	8
1995	2475.0	2473.1	2465.3	2454.1	2439.6	2426.6	2411.9	2403.9	2404.1	2417.8	2446.5	2469.9	2473.6	2475.0	2446.5	71.1	2475.0	1	2403.9	8
1996	2475.0	2473.1	2467.0	2455.4	2440.7	2427.6	2413.4	2405.9	2405.6	2419.5	2448.0	2469.9	2473.6	2475.0	2447.5	69.4	2475.0	1	2405.6	9
1997	2475.0	2473.1	2469.7	2456.3	2441.8	2429.0	2414.4	2407.7	2406.6	2419.5	2447.6	2469.9	2473.6	2475.0	2448.1	68.4	2475.0	1	2406.6	9
1998	2475.0	2473.1	2469.7	2456.2	2441.5	2428.5	2413.9	2405.9	2405.6	2418.8	2447.7	2469.9	2473.6	2475.0	2447.9	69.4	2475.0	1	2405.6	9
1999	2475.0	2473.1	2469.7	2456.3	2441.8	2428.6	2414.4	2407.2	2406.0	2419.5	2448.3	2469.9	2473.6	2475.0	2448.1	69.0	2475.0	1	2406.0	9
2000	2475.0	2473.1	2469.7	2456.6	2442.9	2429.6	2415.8	2409.6	2409.3	2422.5	2451.4	2469.9	2473.6	2475.0	2449.2	65.7	2475.0	1	2409.3	9
2001	2475.0	2473.1	2469.7	2456.6	2441.9	2429.2	2415.5	2407.8	2407.6	2419.7	2448.3	2469.9	2473.6	2475.0	2448.4	67.4	2475.0	1	2407.6	9
2002	2475.0	2473.1	2469.7	2456.4	2441.8	2429.0	2414.6	2407.7	2407.0	2421.8	2448.5	2469.9	2473.6	2475.0	2448.5	68.0	2475.0	1	2407.0	9
2003	2475.0	2473.1	2469.7	2456.6	2442.0	2429.3	2415.5	2407.7	2407.6	2422.1	2449.1	2469.9	2473.6	2475.0	2448.7	67.4	2475.0	1	2407.6	9
2004	2475.0	2473.1	2469.7	2456.6	2442.4	2429.6	2415.8	2408.6	2408.7	2422.5	2451.4	2469.9	2473.6	2475.0	2449.1	66.4	2475.0	1	2408.6	8
2005	2475.0	2473.1	2469.7	2456.6	2442.6	2429.6	2415.8	2408.6	2408.7	2421.9	2448.5	2469.9	2473.6	2475.0	2448.8	66.4	2475.0	1	2408.6	8
2006	2475.0	2473.1	2469.7	2457.6	2443.2	2430.0	2416.6	2409.6	2409.2	2424.4	2450.5	2469.9	2473.6	2475.0	2449.5	65.8	2475.0	1	2409.2	9
2007	2475.0	2473.1	2469.7	2457.6	2443.2	2430.1	2416.6	2409.6	2409.3	2421.9	2449.1	2469.9	2473.6	2475.0	2449.2	65.7	2475.0	1	2409.3	9
2008	2475.0	2473.1	2469.7	2459.1	2444.4	2431.1	2417.0	2410.0	2410.2	2422.3	2451.4	2469.9	2473.6	2475.0	2449.8	65.0	2475.0	1	2410.0	8
AVG	2471.4	2468.5	2463.8	2450.7	2436.5	2425.0	2411.4	2404.8	2404.5	2418.6	2446.9	2469.4	2472.5	2473.6						
RNG	19.4	19.5	22.2	30.6	31.7	23.2	21.9	21.3	21.4	17.3	13.3	8.1	7.1	7.2						
SDEV	6.0	7.7	9.0	9.9	9.5	7.3	6.7	5.9	5.9	4.8	3.9	1.7	2.1	2.6						
FMAX	2475.0	2473.1	2469.7	2459.1	2444.4	2431.1	2417.0	2410.0	2410.2	2424.4	2451.4	2470.8	2473.6	2475.0						
FMIN	2455.6	2453.6	2447.5	2428.5	2412.7	2407.9	2395.1	2388.7	2388.8	2407.1	2438.1	2462.7	2466.5	2467.8						
MXYR	1995	1995	1997	2008	2008	2008	2008	2008	2008	2006	2000	1990	1994	1994						
MNYR	1989	1989	1989	1989	1989	1989	1989	1993	1993	1993	1989	1993	1993	1989						

Figure A6.1.1 Maximum, mean and minimum median monthly hydrograph of elevations, Mica Reservoir, Base Case (AOS)

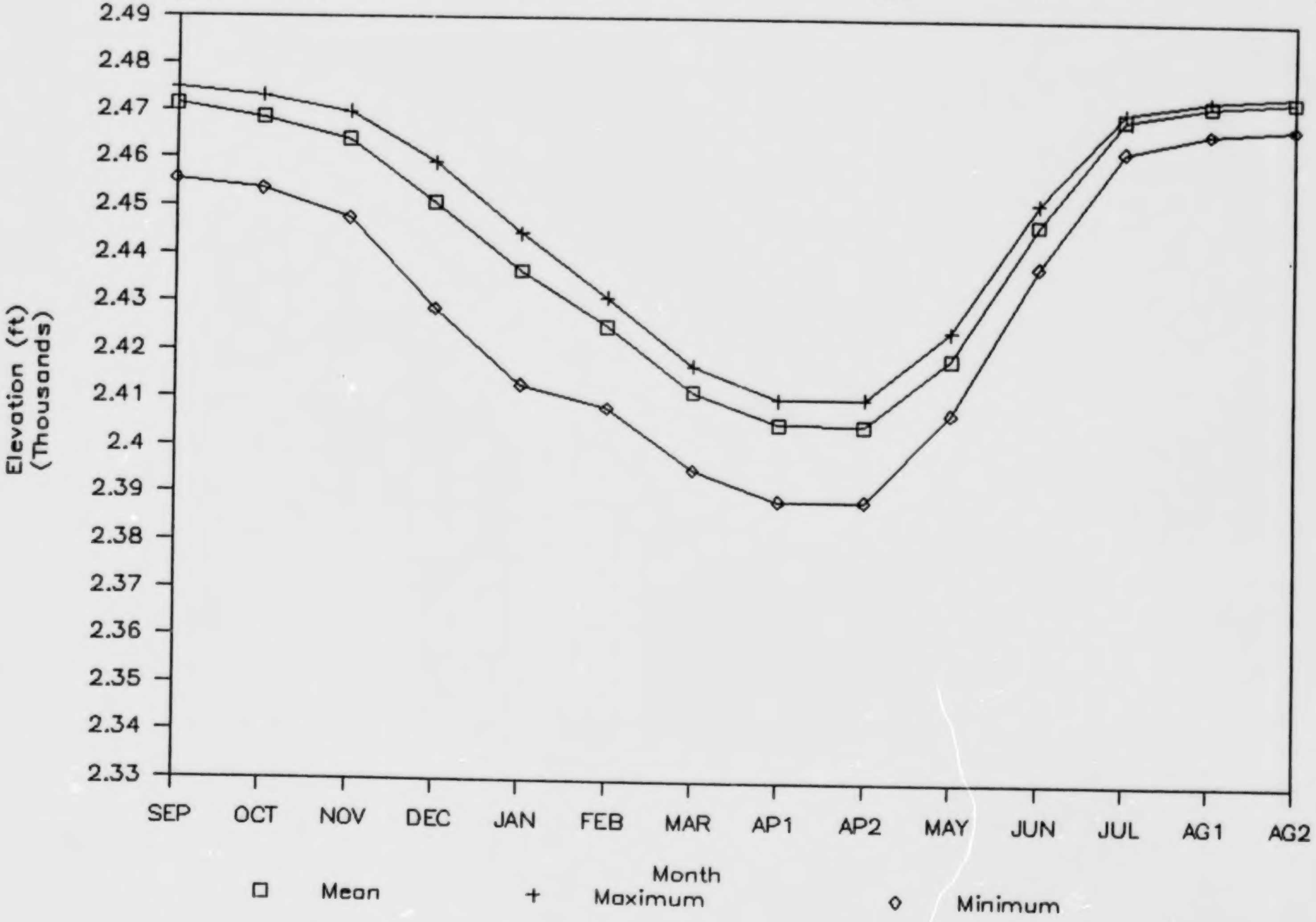


Table A6.1.2 Summary table of median (50% exceedance) outflows, Mica Reservoir, Base Case (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	20838.0	14470.0	18123.0	34000.0	28000.0	9528.0	17000.0	15000.0	10000.0	10000.0	10000.0	21455.0	34757.0	33717.0	19179.3	25229.0	34757.0	13	9528.0	6
1990	27901.0	17792.0	18332.0	26000.0	26000.0	20923.0	17000.0	15000.0	10000.0	10000.0	10000.0	26304.0	37676.0	34089.0	20719.5	27676.0	37676.0	13	10000.0	9
1991	30537.0	20759.0	18326.0	27000.0	27000.0	16900.0	20000.0	15000.0	10000.0	10000.0	10000.0	26459.0	38375.0	38249.0	21482.8	28375.0	38375.0	13	10000.0	9
1992	32226.0	20487.0	18332.0	23000.0	23000.0	20188.0	18000.0	18000.0	18000.0	10000.0	10000.0	27162.0	41171.0	35159.0	21546.7	31171.0	41171.0	13	10000.0	10
1993	32227.0	21410.0	14809.0	27000.0	27000.0	25000.0	22052.0	26616.0	10000.0	10000.0	10000.0	23975.0	32996.0	32037.0	22024.8	22996.0	32996.0	13	10000.0	9
1994	21098.0	14750.0	15058.0	27000.0	27000.0	25000.0	23000.0	26590.0	10000.0	10000.0	10000.0	26870.0	32434.0	32037.0	20858.9	22434.0	32434.0	13	10000.0	9
1995	20838.0	14750.0	14898.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	24231.0	32996.0	32037.0	20644.5	22996.0	32996.0	13	10000.0	9
1996	20838.0	15080.0	14898.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28018.0	33006.0	32457.0	21005.5	23006.0	33006.0	13	10000.0	9
1997	21038.0	15420.0	14277.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	26028.0	32996.0	32037.0	20815.0	22996.0	32996.0	13	10000.0	9
1998	21038.0	15080.0	14698.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27436.0	32996.0	31573.0	20919.7	22996.0	32996.0	13	10000.0	9
1999	21038.0	15310.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	26155.0	32996.0	32457.0	20827.3	22996.0	32996.0	13	10000.0	9
2000	20518.0	15080.0	14028.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30960.0	33006.0	32457.0	20734.8	23006.0	33006.0	13	10000.0	9
2001	21238.0	14750.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	32996.0	32037.0	20850.2	22996.0	32996.0	13	10000.0	9
2002	21038.0	15080.0	14198.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28877.0	32996.0	32037.0	21017.5	22996.0	32996.0	13	10000.0	9
2003	21038.0	14750.0	13989.0	27000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	27000.0	33006.0	32037.0	20816.5	23006.0	33006.0	13	10000.0	9
2004	20518.0	15080.0	13989.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30677.0	33006.0	32560.0	20712.3	23006.0	33006.0	13	10000.0	9
2005	21038.0	14750.0	13989.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28975.0	32996.0	32457.0	20581.5	22996.0	32996.0	13	10000.0	9
2006	21038.0	14750.0	13061.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30173.0	33406.0	32560.0	20625.4	23406.0	33406.0	13	10000.0	9
2007	21098.0	15310.0	14198.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	28975.0	32996.0	32269.0	20642.8	22996.0	32996.0	13	10000.0	9
2008	21038.0	15080.0	14198.0	22000.0	27000.0	25000.0	23000.0	27000.0	10000.0	10000.0	10000.0	30876.0	33406.0	32519.0	20804.5	23406.0	33406.0	13	10000.0	9
AVG	22908.9	15996.9	15089.8	25600.0	26800.0	23376.9	21952.6	24710.3	10400.0	10000.0	10000.0	27380.3	34010.6	32839.1						
RNG	11709.0	6940.0	5271.0	12000.0	5000.0	15472.0	6000.0	12000.0	8000.0	0.0	0.0	9505.0	8737.0	6676.0						
SDEV	4093.6	2216.5	1694.0	3050.5	951.5	3920.8	2114.6	4636.6	1788.9	0.0	0.0	2449.4	2303.7	1526.2						
FMAX	32227.0	21410.0	18332.0	34000.0	28000.0	25000.0	23000.0	27000.0	18000.0	10000.0	10000.0	30960.0	41171.0	38249.0						
FMIN	20518.0	14470.0	13061.0	22000.0	23000.0	9528.0	17000.0	15000.0	10000.0	10000.0	10000.0	21455.0	32434.0	31573.0						
MXYR	1993	1993	1990	1989	1989	1993	1994	1995	1992	1989	1989	2000	1992	1991						
MNYR	2000	1989	2006	2000	1992	1989	1989	1989	1989	1989	1989	1989	1994	1998						

Figure A6.1.2 Maximum, mean and minimum median monthly hydrograph of outflows, Mica Reservoir, Base Case (AOS)

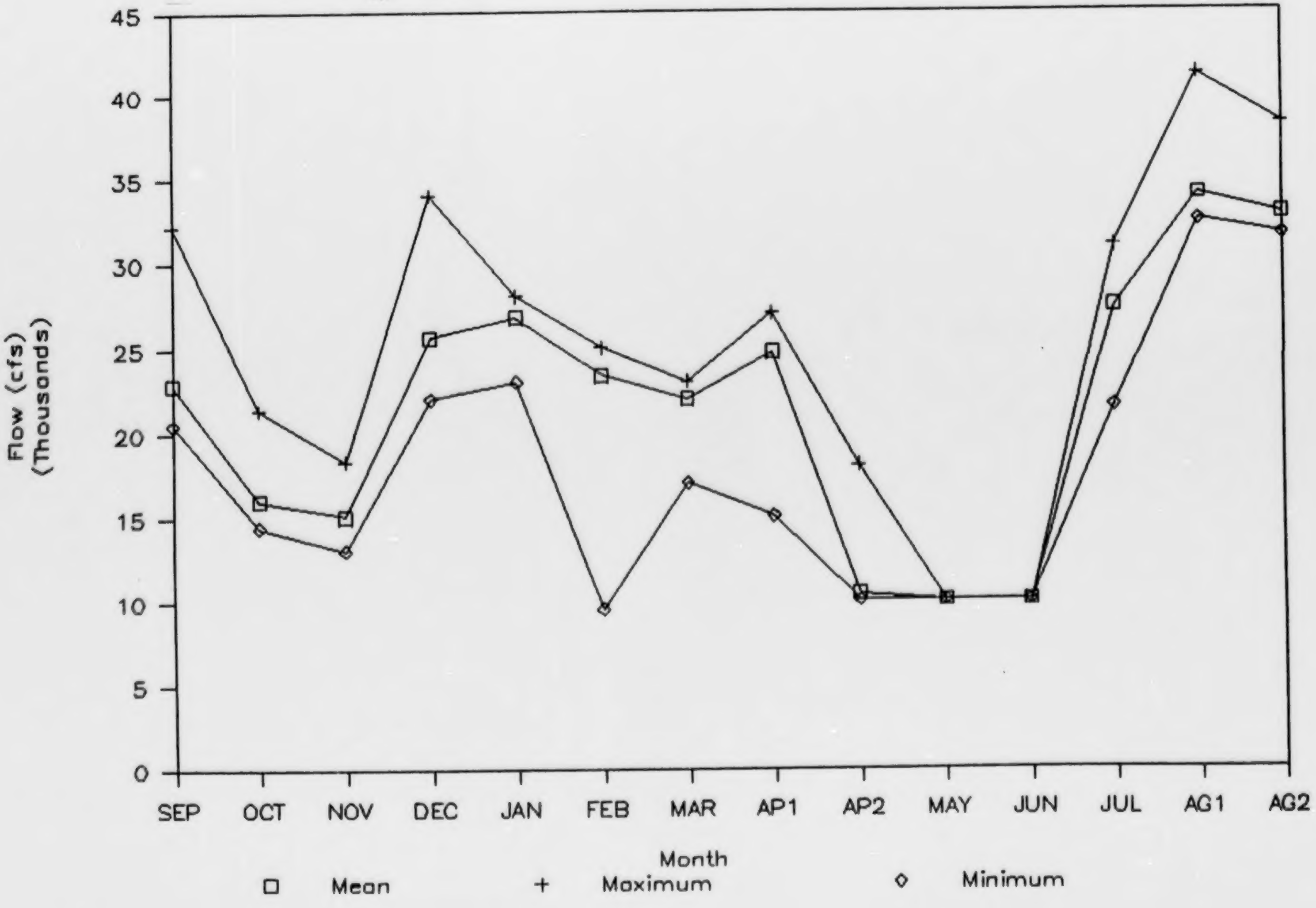


Table A6.1.3 Summary table of median (50% exceedance) elevations, Arrow Lakes Reservoir, Base Case (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	1444.0	1441.9	1438.1	1433.3	1408.9	1399.2	1398.4	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.2	45.6	1444.0	1	1398.4	7
1990	1444.0	1441.9	1438.9	1431.6	1406.6	1396.4	1395.9	1399.9	1399.9	1414.6	1435.3	1444.0	1444.0	1444.0	1424.4	48.1	1444.0	1	1395.9	7
1991	1444.0	1441.9	1439.3	1432.9	1408.6	1399.8	1398.2	1399.9	1399.9	1415.2	1436.2	1444.0	1444.0	1444.0	1425.3	45.8	1444.0	1	1398.2	7
1992	1444.0	1441.9	1439.9	1432.7	1406.2	1398.1	1396.2	1399.5	1399.9	1415.2	1437.0	1444.0	1444.0	1444.0	1424.9	47.8	1444.0	1	1396.2	7
1993	1443.9	1441.9	1439.1	1434.8	1407.6	1400.3	1399.4	1399.9	1401.3	1415.2	1435.3	1444.0	1444.0	1444.0	1425.5	44.6	1444.0	12	1399.4	7
1994	1443.7	1440.4	1439.9	1436.2	1410.7	1401.0	1399.9	1399.9	1399.9	1414.6	1435.7	1444.0	1444.0	1444.0	1425.8	44.1	1444.0	12	1399.9	7
1995	1443.5	1440.5	1440.0	1436.2	1409.9	1400.1	1398.8	1399.9	1400.6	1414.6	1435.6	1444.0	1444.0	1444.0	1425.6	45.2	1444.0	12	1398.8	7
1996	1443.6	1440.9	1440.9	1436.2	1412.1	1403.9	1399.9	1399.9	1399.9	1413.0	1435.9	1444.0	1444.0	1444.0	1426.2	44.1	1444.0	12	1399.9	7
1997	1443.7	1441.5	1440.6	1436.2	1411.0	1402.5	1399.9	1399.9	1400.7	1413.2	1435.6	1444.0	1444.0	1444.0	1426.0	44.1	1444.0	12	1399.9	7
1998	1443.7	1441.0	1439.5	1435.3	1409.3	1400.2	1399.6	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.6	44.4	1444.0	12	1399.6	7
1999	1443.8	1441.9	1439.8	1435.4	1410.2	1402.0	1399.9	1399.9	1403.3	1415.2	1437.3	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	12	1399.9	7
2000	1443.9	1441.9	1441.6	1436.2	1412.8	1403.7	1399.9	1399.9	1401.8	1415.2	1435.3	1444.0	1444.0	1444.0	1426.6	44.1	1444.0	12	1399.9	7
2001	1443.7	1441.2	1441.1	1436.2	1412.3	1403.7	1399.9	1399.9	1401.2	1415.2	1435.4	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	12	1399.9	7
2002	1443.8	1441.3	1439.9	1435.1	1410.5	1400.7	1399.9	1399.9	1403.4	1415.2	1437.0	1444.0	1444.0	1444.0	1426.1	44.1	1444.0	12	1399.9	7
2003	1443.8	1441.6	1440.7	1436.2	1412.3	1404.4	1399.9	1399.9	1403.4	1415.2	1437.3	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	12	1399.9	7
2004	1443.8	1441.9	1441.6	1436.2	1413.5	1404.5	1399.9	1399.9	1401.5	1415.2	1437.3	1444.0	1444.0	1444.0	1426.9	44.1	1444.0	12	1399.9	7
2005	1443.8	1441.7	1441.6	1436.2	1413.1	1405.0	1399.9	1399.9	1403.2	1415.2	1437.5	1444.0	1444.0	1444.0	1427.0	44.1	1444.0	12	1399.9	7
2006	1443.8	1441.9	1441.8	1436.2	1413.8	1406.7	1399.9	1399.9	1403.9	1415.3	1435.6	1444.0	1444.0	1444.0	1427.1	44.1	1444.0	12	1399.9	7
2007	1443.8	1441.9	1441.6	1436.2	1411.1	1402.1	1399.9	1399.9	1403.4	1415.2	1436.1	1444.0	1444.0	1444.0	1426.5	44.1	1444.0	12	1399.9	7
2008	1443.9	1441.8	1442.1	1436.2	1413.4	1403.6	1399.4	1399.9	1401.5	1415.2	1435.5	1444.0	1444.0	1444.0	1426.7	44.6	1444.0	12	1399.4	7
AVG	1443.8	1441.5	1440.4	1435.3	1410.7	1401.9	1399.2	1399.9	1401.4	1414.9	1436.1	1444.0	1444.0	1444.0						
RNG	0.5	1.5	4.0	4.6	7.6	10.3	4.0	0.4	4.0	2.3	2.2	0.0	0.0	0.0						
SDEV	0.1	0.5	1.1	1.5	2.3	2.6	1.2	0.1	1.5	0.7	0.8	0.0	0.0	0.0						
FMAX	1444.0	1441.9	1442.1	1436.2	1413.8	1406.7	1399.9	1399.9	1403.9	1415.3	1437.5	1444.0	1444.0	1444.0						
FMIN	1443.5	1440.4	1438.1	1431.6	1406.2	1396.4	1395.9	1399.5	1399.9	1413.0	1435.3	1444.0	1444.0	1444.0						
MXYR	1989	1989	2008	1994	2006	2006	1994	1989	2006	2006	2005	1989	1989	1989						
MNYR	1995	1994	1989	1990	1992	1990	1990	1992	1989	1996	1990	1989	1989	1989						

Figure A6.1.3 Maximum, mean and minimum median monthly hydrograph of elevations, Arrow Lakes Reservoir, Base Case (AOS)

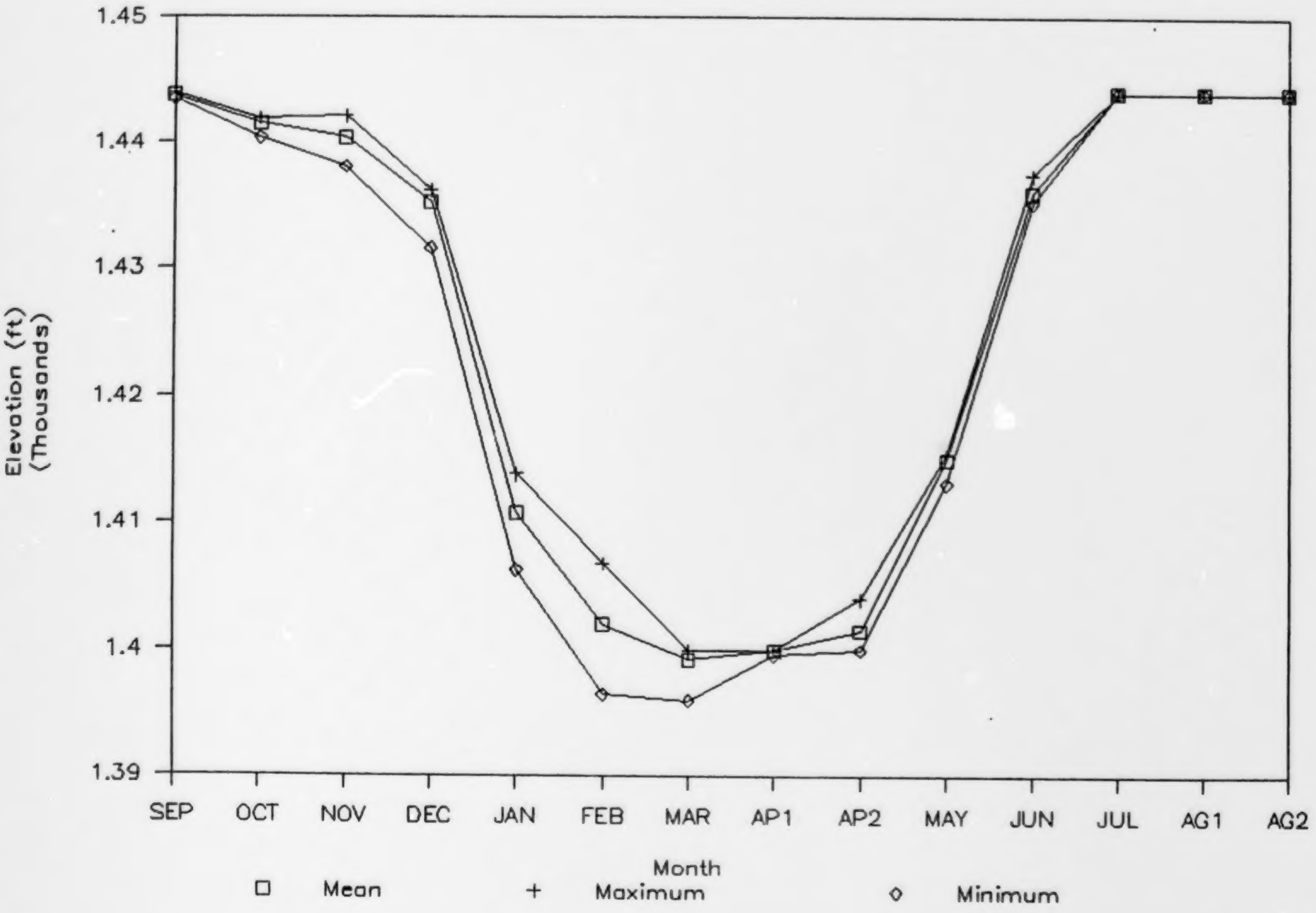
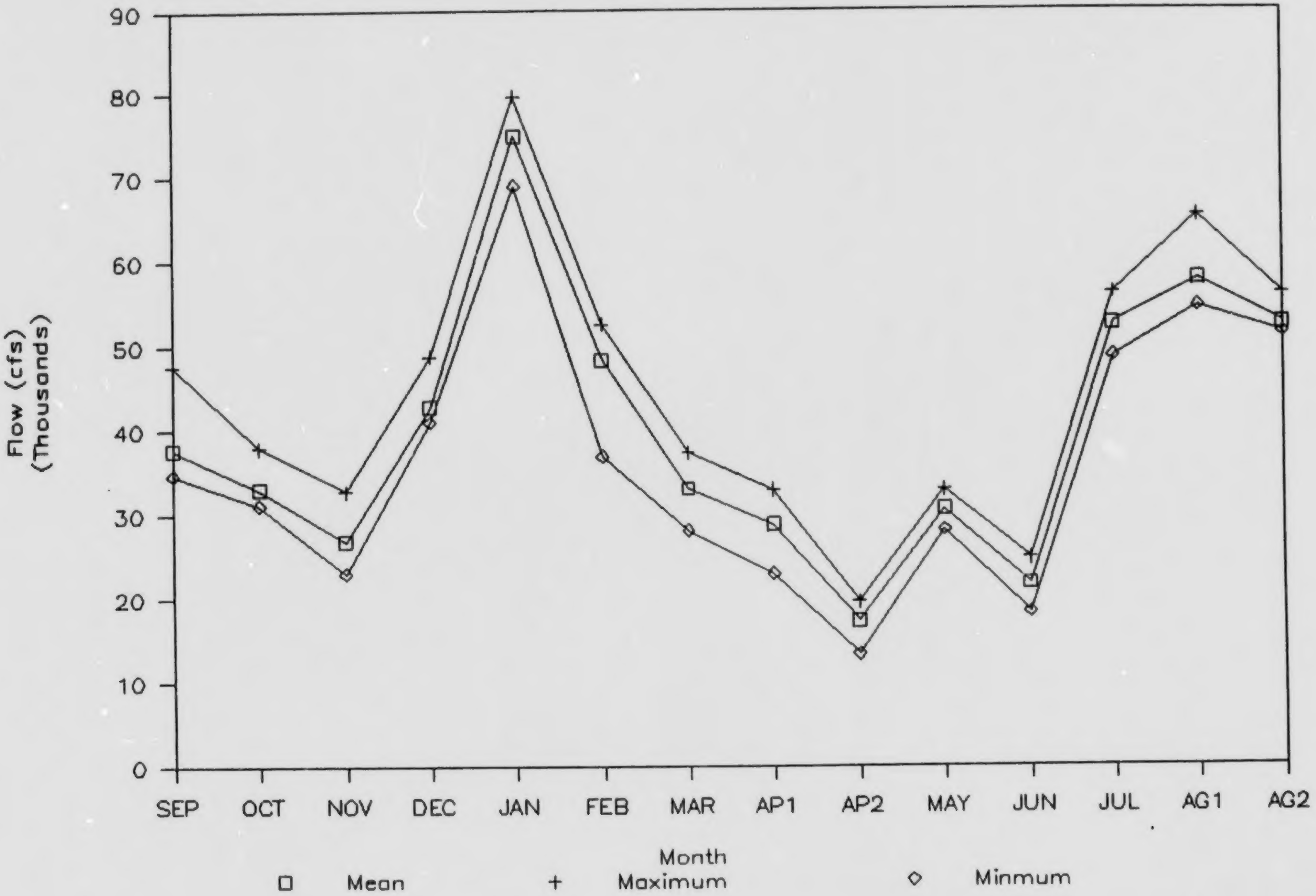


Table A6.1.4 Summary table of median (50% exceedance) outflows, Arrow Lakes Reservoir, Base Case (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	34978.0	33627.0	32758.0	48765.0	75729.0	36846.0	28006.0	22886.0	13235.0	27982.0	21126.0	48586.0	60493.0	52870.0	38595.4	62494.0	75729.0	5	13235.0	9
1990	42906.0	35596.0	32000.0	47722.0	70609.0	42511.0	28652.0	22886.0	17846.0	28903.0	22656.0	50157.0	63132.0	53103.0	40016.3	52763.0	70609.0	5	17846.0	9
1991	45786.0	36021.0	30943.0	45602.0	74526.0	41468.0	30338.0	22841.0	15192.0	28903.0	21841.0	53097.0	60493.0	55982.0	40481.6	59334.0	74526.0	5	15192.0	9
1992	47117.0	37872.0	30117.0	43022.0	72244.0	41938.0	28529.0	22834.0	17797.0	28903.0	20740.0	50995.0	65172.0	54044.0	40116.7	54447.0	72244.0	5	17797.0	9
1993	47682.0	37899.0	28579.0	42119.0	78529.0	44217.0	30098.0	26444.0	13284.0	28555.0	22306.0	51157.0	54629.0	52598.0	40384.9	65245.0	78529.0	5	13284.0	9
1994	36974.0	33259.0	26521.0	41805.0	76094.0	46654.0	31644.0	29276.0	16459.0	29762.0	18568.0	51513.0	54629.0	51282.0	39051.4	59635.0	76094.0	5	16459.0	9
1995	36455.0	32774.0	26422.0	41988.0	79658.0	46160.0	31957.0	28470.0	16843.0	29811.0	19476.0	50795.0	56677.0	51797.0	39365.8	62815.0	79658.0	5	16843.0	9
1996	36227.0	32522.0	26135.0	41763.0	71507.0	51721.0	34718.0	30568.0	19487.0	32097.0	19476.0	55971.0	54629.0	52277.0	40051.5	52031.0	71507.0	5	19476.0	11
1997	36304.0	33373.0	26552.0	42003.0	76077.0	51721.0	32931.0	29486.0	17846.0	32206.0	18166.0	51157.0	58603.0	52870.0	39991.0	58231.0	76077.0	5	17846.0	9
1998	36020.0	32638.0	27391.0	42470.0	78067.0	51721.0	32417.0	29486.0	17846.0	32509.0	22306.0	50795.0	57262.0	51650.0	40371.3	60221.0	78067.0	5	17846.0	9
1999	36156.0	32177.0	26229.0	42288.0	74599.0	51488.0	34718.0	29486.0	17347.0	31163.0	19983.0	51157.0	58492.0	51642.0	39870.1	57252.0	74599.0	5	17347.0	9
2000	34728.0	31654.0	25316.0	41734.0	74859.0	52529.0	35800.0	32870.0	17877.0	31148.0	24286.0	55971.0	58685.0	53486.0	40790.3	56982.0	74859.0	5	17877.0	9
2001	35071.0	31600.0	25890.0	41703.0	76930.0	51721.0	34718.0	31797.0	17877.0	29777.0	21282.0	51157.0	54629.0	51395.0	39808.2	59053.0	76930.0	5	17877.0	9
2002	36203.0	32258.0	26739.0	42848.0	76139.0	46105.0	32426.0	29486.0	17347.0	30589.0	22529.0	52654.0	54459.0	51630.0	39579.3	58792.0	76139.0	5	17347.0	9
2003	34726.0	31279.0	24463.0	41810.0	74948.0	51825.0	35261.0	29486.0	17347.0	32838.0	22306.0	51421.0	58195.0	51530.0	39929.7	57601.0	74948.0	5	17347.0	9
2004	34920.0	31461.0	23854.0	41627.0	72960.0	51721.0	37191.0	32870.0	17877.0	30124.0	23518.0	55971.0	55339.0	52870.0	40235.4	55083.0	72960.0	5	17877.0	9
2005	35815.0	31184.0	24361.0	41200.0	73907.0	51721.0	34718.0	31284.0	19100.0	30262.0	22078.0	52513.0	54459.0	51642.0	39666.8	54807.0	73907.0	5	19100.0	9
2006	34808.0	31156.0	23021.0	40894.0	68900.0	49887.0	35067.0	32698.0	17877.0	32150.0	24663.0	51338.0	56352.0	51642.0	39264.0	51023.0	68900.0	5	17877.0	9
2007	36121.0	31597.0	25084.0	41763.0	78067.0	51721.0	34471.0	29486.0	17846.0	30689.0	22529.0	56134.0	58683.0	51282.0	40568.7	60221.0	78067.0	5	17846.0	9
2008	35121.0	31366.0	24172.0	41535.0	73095.0	52529.0	35735.0	29486.0	17877.0	30605.0	21790.0	55849.0	59715.0	52690.0	40140.1	55218.0	73095.0	5	17877.0	9
AVG	37705.9	33065.6	26827.3	42733.1	74872.2	48310.2	32969.8	28706.3	17210.3	30448.8	21581.3	52419.4	57736.4	52414.1						
RNG	12956.0	6743.0	9737.0	7871.0	10758.0	15683.0	9185.0	10036.0	6252.0	4856.0	6497.0	7548.0	10713.0	4700.0						
SDEV	4324.0	2129.9	2738.7	2119.8	2774.2	4720.8	2706.4	3376.9	1605.7	1415.4	1756.4	2298.8	3043.2	1158.8						
FMAX	47682.0	37899.0	32758.0	48765.0	79658.0	52529.0	37191.0	32870.0	19487.0	32838.0	24663.0	56134.0	65172.0	55982.0						
FMIN	34726.0	31156.0	23021.0	40894.0	68900.0	36846.0	28006.0	22834.0	13235.0	27982.0	18166.0	48586.0	54459.0	51282.0						
MXYR	1993	1993	1989	1989	1995	2000	2004	2000	1996	2003	2006	2007	1992	1991						
MNYR	2003	2006	2006	2006	2006	1989	1989	1992	1989	1989	1997	1989	2002	1994						

Figure A6.1.4 Maximum, mean and minimum median monthly hydrograph of outflows, Arrow Lakes Reservoir, Base Case (AOS)



APPENDIX 6.2

Regime 1 (AOS)

Table A6.2.1 Summary table of median (50% exceedance) elevations, Mica Reservoir, Regime 1 (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	2455.6	2453.6	2447.5	2428.5	2412.7	2407.9	2395.1	2391.5	2391.2	2407.3	2438.1	2467.4	2468.1	2467.8	2431.1	76.9	2468.1	13	2391.2	9
1990	2464.6	2457.7	2444.5	2425.2	2411.3	2406.6	2395.6	2390.9	2389.5	2404.7	2440.7	2462.0	2464.7	2464.4	2430.6	75.2	2464.7	13	2389.5	9
1991	2457.3	2450.9	2438.3	2422.0	2403.4	2395.5	2381.7	2373.5	2372.8	2389.5	2426.9	2455.5	2456.9	2457.0	2420.9	84.5	2457.3	1	2372.8	9
1992	2449.5	2441.7	2430.8	2415.2	2398.5	2387.5	2375.1	2369.4	2364.6	2388.1	2423.1	2448.4	2450.1	2450.4	2414.6	85.8	2450.4	14	2364.6	9
1993	2445.1	2436.3	2426.8	2410.1	2392.1	2377.7	2361.3	2351.3	2353.7	2377.7	2414.6	2441.5	2443.5	2442.8	2406.6	93.8	2445.1	1	2351.3	8
1994	2435.6	2427.3	2417.7	2405.5	2387.3	2369.9	2351.9	2342.2	2345.0	2369.9	2404.8	2430.8	2432.8	2431.4	2398.0	93.4	2435.6	1	2342.2	8
1995	2424.9	2421.7	2417.7	2404.2	2385.1	2366.5	2351.4	2342.4	2341.8	2368.6	2405.9	2431.4	2435.1	2433.8	2396.2	93.3	2435.1	13	2341.8	9
1996	2426.6	2421.7	2417.7	2405.0	2386.8	2370.3	2351.6	2343.3	2345.1	2368.6	2404.1	2431.2	2434.7	2434.1	2396.9	91.4	2434.7	13	2343.3	8
1997	2425.9	2421.7	2417.7	2405.5	2387.5	2371.3	2353.0	2342.6	2345.1	2365.6	2402.6	2433.5	2436.6	2435.6	2397.0	94.0	2436.6	13	2342.6	8
1998	2431.3	2427.7	2421.5	2408.1	2389.8	2376.2	2358.7	2349.0	2350.4	2371.7	2411.9	2437.7	2440.9	2439.9	2402.1	91.9	2440.9	13	2349.0	8
1999	2434.2	2430.1	2424.7	2411.6	2396.1	2381.0	2362.7	2354.3	2356.2	2377.9	2416.7	2444.0	2448.6	2448.0	2406.8	94.3	2448.6	13	2354.3	8
2000	2442.1	2436.8	2428.2	2416.0	2399.7	2387.3	2373.7	2365.2	2365.2	2389.2	2427.5	2449.8	2452.9	2453.5	2414.1	88.3	2453.5	14	2365.2	8
2001	2447.3	2438.0	2430.9	2414.4	2395.3	2380.4	2364.0	2354.5	2354.3	2379.8	2415.1	2443.4	2445.7	2445.3	2409.0	93.0	2447.3	1	2354.3	9
2002	2437.7	2432.2	2426.1	2410.7	2392.0	2374.6	2355.5	2346.7	2347.9	2373.7	2405.1	2435.1	2437.3	2436.7	2402.2	91.0	2437.7	1	2346.7	8
2003	2433.5	2429.1	2422.0	2409.4	2394.2	2383.1	2369.2	2359.3	2360.3	2383.9	2420.7	2445.6	2448.3	2448.6	2408.2	89.3	2448.6	14	2359.3	8
2004	2440.3	2432.8	2425.1	2411.4	2396.8	2384.1	2369.7	2360.2	2361.9	2386.5	2424.0	2448.4	2450.2	2449.6	2410.8	90.0	2450.2	13	2360.2	8
2005	2441.5	2434.1	2426.3	2413.5	2397.2	2381.3	2364.5	2356.9	2358.3	2380.2	2416.0	2439.9	2442.9	2443.8	2408.0	86.9	2443.8	14	2356.9	8
2006	2435.5	2429.7	2420.7	2408.2	2390.1	2372.9	2358.2	2350.0	2352.7	2378.5	2411.6	2438.0	2439.4	2439.0	2402.8	89.4	2439.4	13	2350.0	8
2007	2433.9	2425.3	2419.9	2408.6	2390.9	2374.3	2358.0	2349.3	2349.8	2371.1	2407.1	2435.3	2438.2	2438.1	2401.0	88.9	2438.2	13	2349.3	8
2008	2429.5	2421.8	2417.7	2405.8	2390.7	2379.2	2362.7	2353.2	2353.3	2375.5	2413.0	2438.8	2440.5	2440.9	2402.4	87.7	2440.9	14	2353.2	8
AVG	2439.6	2433.5	2426.1	2411.9	2394.9	2381.4	2365.7	2357.3	2358.0	2380.4	2416.4	2442.9	2445.4	2445.0						
RNG	39.7	36.0	29.8	24.3	27.6	41.4	44.2	49.3	49.4	41.7	38.1	36.6	35.3	36.4						
SDEV	10.9	10.6	8.8	6.8	7.5	11.3	13.1	14.5	13.6	11.3	10.9	10.1	9.7	10.0						
FMAX	2464.6	2457.7	2447.5	2428.5	2412.7	2407.9	2395.6	2391.5	2391.2	2407.3	2440.7	2467.4	2468.1	2467.8						
FMIN	2424.9	2421.7	2417.7	2404.2	2385.1	2366.5	2351.4	2342.2	2341.8	2365.6	2402.6	2430.8	2432.8	2431.4						
MXYR	1990	1990	1989	1989	1989	1989	1990	1989	1989	1989	1990	1989	1989	1989						
MNYR	1995	1995	1994	1995	1995	1995	1995	1994	1995	1997	1997	1994	1994	1994						

Figure A6.2.1 Maximum, mean and minimum median monthly hydrograph of elevations, Mica Reservoir, Regime 1 (AOS)

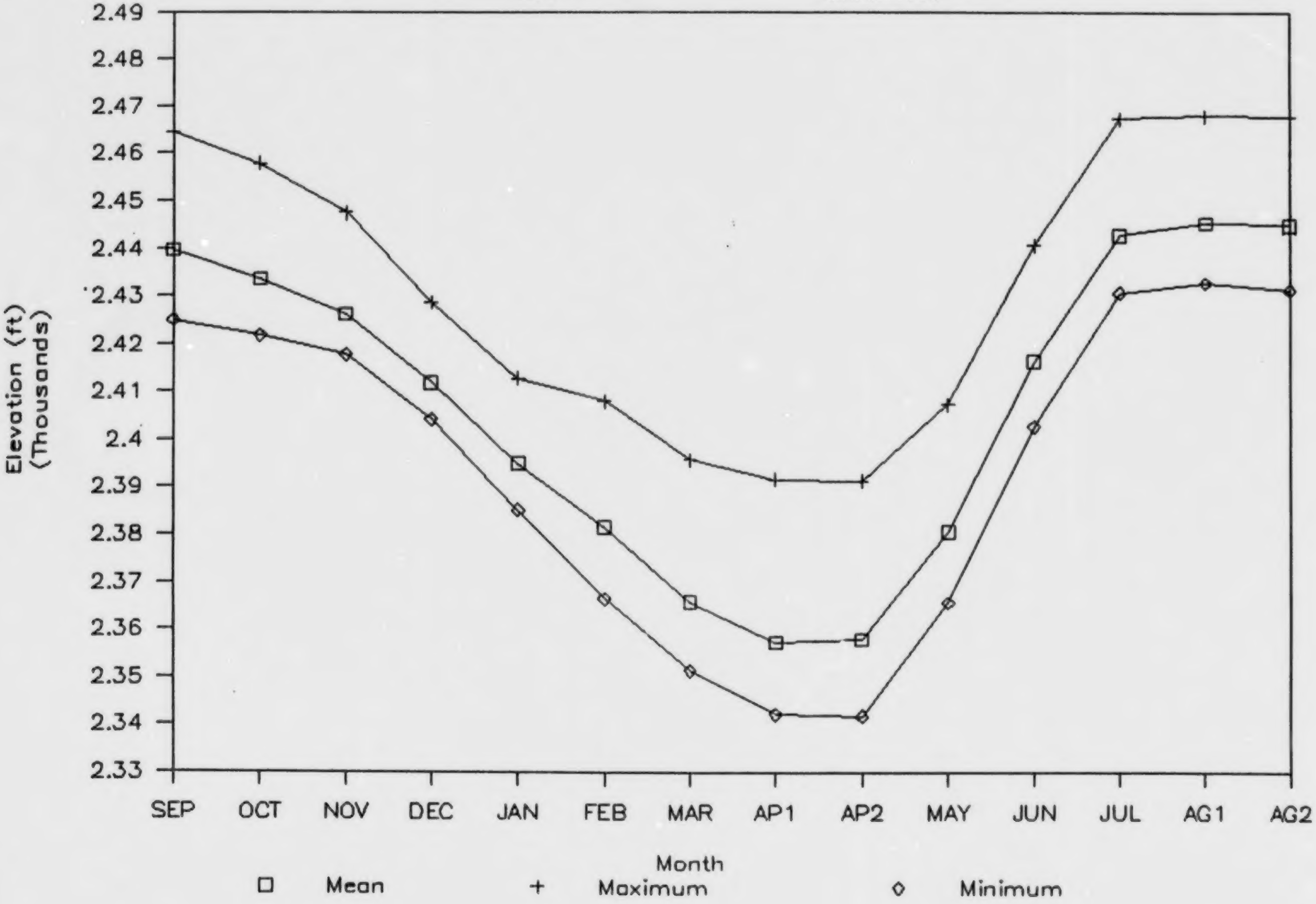


Table A6.2.2 Summary table of median (50% exceedance) outflows, Mica Reservoir, Regime 1 (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	20838.0	14470.0	18123.0	34000.0	28000.0	9528.0	17000.0	15000.0	10000.0	10000.0	10000.0	21455.0	34757.0	33717.0	19179.3	25229.0	34757.0	13	9528.0	6
1990	27901.0	26319.0	25453.0	32985.0	26000.0	18657.0	17000.0	15000.0	10000.0	10000.0	10000.0	25760.0	37439.0	34581.0	22382.1	27439.0	37439.0	13	10000.0	9
1991	32238.0	24676.0	23048.0	27224.0	27000.0	12000.0	20000.0	15000.0	10000.0	10000.0	10000.0	24131.0	37179.0	37779.0	21691.3	27779.0	37779.0	14	10000.0	9
1992	32227.0	25653.0	22466.0	23000.0	23000.0	19912.0	14917.0	18000.0	18000.0	10000.0	9405.0	22756.0	40639.0	34759.0	21586.3	31234.0	40639.0	13	9405.0	11
1993	32227.0	25847.0	21945.0	27000.0	27000.0	25000.0	20621.0	23914.0	10000.0	10000.0	8003.0	19437.0	36629.0	35446.0	22506.2	28626.0	36629.0	13	8003.0	11
1994	32816.0	24637.0	22482.0	27000.0	27000.0	25000.0	22517.0	22000.0	10000.0	10000.0	10000.0	21549.0	36629.0	34329.0	22873.3	26629.0	36629.0	13	10000.0	9
1995	29788.0	18340.0	21232.0	27000.0	27000.0	25000.0	18218.0	22000.0	10000.0	10000.0	10000.0	19939.0	34485.0	33059.0	21390.8	24485.0	34485.0	13	10000.0	9
1996	29851.0	20235.0	19004.0	27000.0	27000.0	25000.0	20681.0	22000.0	10000.0	10000.0	10000.0	20472.0	36629.0	34940.0	21752.3	26629.0	36629.0	13	10000.0	9
1997	28610.0	18340.0	18150.0	27000.0	27000.0	25000.0	21069.0	22000.0	10000.0	10000.0	9046.0	20294.0	34588.0	33727.0	21222.2	25542.0	34588.0	13	9046.0	11
1998	27000.0	16750.0	15619.0	27000.0	27000.0	25000.0	21473.0	23218.0	10000.0	10000.0	5481.0	20570.0	35314.0	33717.0	20584.8	29833.0	35314.0	13	5481.0	11
1999	28538.0	19502.0	15358.0	27000.0	27000.0	22297.0	20032.0	27000.0	10000.0	10000.0	8827.0	19437.0	34000.0	32560.0	20814.3	25173.0	34000.0	13	8827.0	11
2000	31334.0	19150.0	15433.0	24436.0	27000.0	20571.0	17196.0	22814.0	10000.0	10000.0	10000.0	23774.0	36438.0	33871.0	20871.3	26438.0	36438.0	13	10000.0	9
2001	32238.0	23304.0	18509.0	27000.0	27000.0	25000.0	18412.0	23494.0	10000.0	10000.0	7371.0	22291.0	36316.0	33871.0	21913.8	28945.0	36316.0	13	7371.0	11
2002	29956.0	20732.0	17256.0	27000.0	27000.0	25000.0	23000.0	22735.0	10000.0	10000.0	8501.0	22609.0	34704.0	33871.0	21809.1	26203.0	34704.0	13	8501.0	11
2003	27000.0	16888.0	15016.0	23514.0	27000.0	20060.0	16917.0	23492.0	10000.0	10000.0	9400.0	23101.0	35621.0	33149.0	20002.3	26221.0	35621.0	13	9400.0	11
2004	32238.0	21403.0	16721.0	22059.0	27000.0	19866.0	18746.0	25007.0	10000.0	10000.0	8480.0	25000.0	36629.0	35326.0	21249.5	28149.0	36629.0	13	8480.0	11
2005	32238.0	22056.0	18740.0	27000.0	27000.0	25000.0	19272.0	23513.0	10000.0	10000.0	8791.0	24602.0	35859.0	35327.0	22254.0	27068.0	35859.0	13	8791.0	11
2006	32236.0	19150.0	15674.0	26427.0	27000.0	25000.0	19822.0	22000.0	10000.0	10000.0	10000.0	23922.0	36629.0	34950.0	21751.7	26629.0	36629.0	13	10000.0	9
2007	29574.0	18655.0	15358.0	26974.0	27000.0	25000.0	20990.0	27000.0	10000.0	10000.0	8241.0	22917.0	36629.0	34600.0	21568.6	28388.0	36629.0	13	8241.0	11
2008	31814.0	18340.0	15300.0	22001.0	27000.0	25000.0	19204.0	23823.0	10000.0	10000.0	10000.0	24839.0	36359.0	33871.0	21293.7	26359.0	36359.0	13	10000.0	9
AVG	30033.1	20722.3	18544.3	26631.0	26000.0	22144.6	19354.3	21950.5	10400.0	10000.0	9077.3	22442.8	36173.6	34412.5						
RNG	11978.0	11849.0	10437.0	11999.0	5000.0	15472.0	8083.0	12000.0	8000.0	0.0	4519.0	6323.0	6639.0	5219.0						
SDEV	2889.2	3397.4	3187.2	2961.2	951.5	4525.5	2075.0	3542.3	1788.9	0.0	1178.9	1969.3	1430.6	1094.8						
FMAX	32816.0	26319.0	25453.0	34000.0	28000.0	25000.0	23000.0	27000.0	18000.0	10000.0	10000.0	25760.0	40639.0	37779.0						
FMIN	20838.0	14470.0	15016.0	22001.0	23000.0	9528.0	14917.0	15000.0	10000.0	10000.0	5481.0	19437.0	34000.0	32560.0						
MXYR	1994	1990	1990	1989	1989	1993	2002	1999	1992	1989	1989	1990	1992	1991						
MNYR	1989	1989	2003	2008	1992	1989	1992	1989	1989	1989	1998	1993	1999	1999						

Figure A6.2.2 Maximum, mean and minimum median monthly hydrograph of outflows, Mica Reservoir, Regime 1 (AOS)

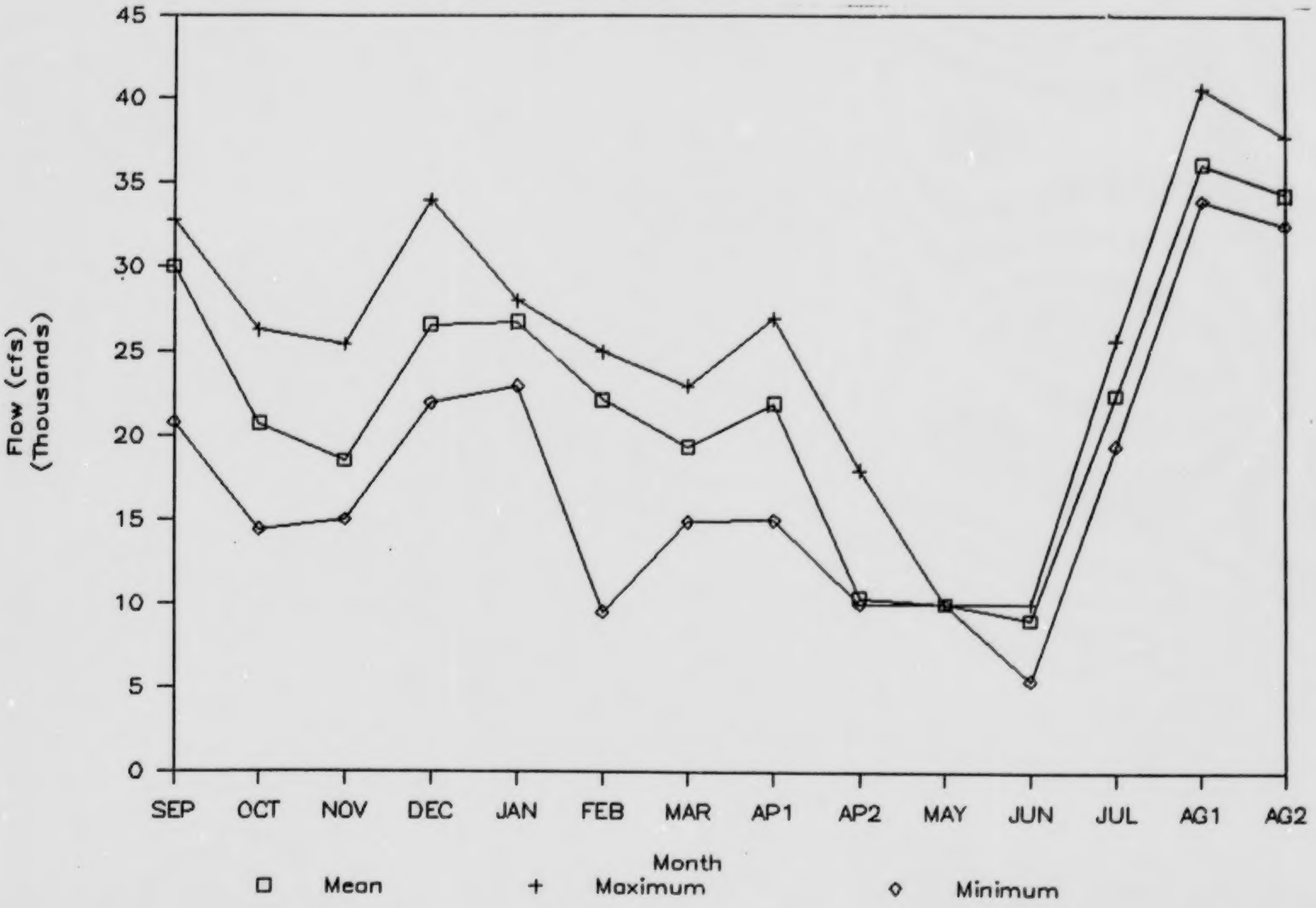


Table A6.2.3 Summary table of median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 1 (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	1444.0	1441.9	1438.1	1433.3	1408.9	1399.2	1398.4	1399.9	1399.9	1415.2	1435.6	1444.0	1444.0	1444.0	1425.2	45.6	1444.0	1	1398.4	7
1990	1444.0	1441.9	1438.9	1432.0	1406.0	1396.4	1393.6	1398.7	1399.9	1414.6	1435.6	1444.0	1444.0	1444.0	1424.2	50.4	1444.0	1	1393.6	7
1991	1444.0	1441.9	1439.2	1433.6	1408.8	1401.0	1399.9	1399.9	1399.9	1415.2	1437.2	1444.0	1444.0	1444.0	1425.7	44.1	1444.0	1	1399.9	7
1992	1444.0	1441.9	1440.0	1433.1	1407.2	1398.2	1397.1	1399.5	1399.9	1414.6	1437.0	1444.0	1444.0	1444.0	1425.1	46.9	1444.0	1	1397.1	7
1993	1444.0	1441.9	1439.4	1435.2	1408.2	1400.2	1399.8	1399.9	1402.0	1415.2	1435.3	1444.0	1444.0	1444.0	1425.7	44.2	1444.0	1	1399.8	7
1994	1444.0	1441.9	1440.5	1436.2	1411.6	1401.7	1399.9	1399.9	1400.2	1414.6	1436.2	1444.0	1444.0	1444.0	1426.2	44.1	1444.0	1	1399.9	7
1995	1444.0	1441.9	1441.1	1436.2	1410.4	1401.3	1398.9	1399.9	1403.1	1414.6	1435.6	1444.0	1444.0	1444.0	1426.1	45.1	1444.0	1	1398.9	7
1996	1444.0	1441.9	1441.3	1436.2	1413.2	1404.5	1399.9	1399.9	1400.5	1413.4	1436.1	1444.0	1444.0	1444.0	1426.6	44.1	1444.0	1	1399.9	7
1997	1444.0	1441.9	1441.1	1436.2	1411.4	1403.3	1399.9	1399.9	1400.9	1414.6	1435.3	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	1	1399.9	7
1998	1444.0	1441.9	1439.5	1435.2	1409.8	1400.3	1399.9	1399.9	1402.6	1415.2	1437.3	1444.0	1444.0	1444.0	1426.0	44.1	1444.0	1	1399.9	7
1999	1444.0	1441.9	1440.0	1435.6	1410.6	1401.9	1399.9	1399.9	1403.4	1415.0	1437.0	1444.0	1444.0	1444.0	1426.3	44.1	1444.0	1	1399.9	7
2000	1444.0	1441.9	1442.1	1436.2	1413.3	1404.3	1399.9	1399.9	1403.4	1415.2	1435.3	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	1	1399.9	7
2001	1444.0	1441.9	1442.0	1436.2	1412.3	1404.2	1399.9	1399.9	1403.0	1415.2	1436.1	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	1	1399.9	7
2002	1444.0	1441.9	1440.0	1435.4	1411.2	1402.3	1399.9	1399.9	1403.4	1415.2	1437.5	1444.0	1444.0	1444.0	1426.4	44.1	1444.0	1	1399.9	7
2003	1444.0	1441.9	1441.5	1436.2	1412.7	1404.9	1399.9	1399.9	1403.4	1415.2	1437.5	1444.0	1444.0	1444.0	1427.0	44.1	1444.0	1	1399.9	7
2004	1444.0	1442.0	1442.1	1436.2	1413.0	1404.6	1399.9	1399.9	1402.0	1415.2	1437.3	1444.0	1444.0	1444.0	1427.0	44.1	1444.0	1	1399.9	7
2005	1444.0	1441.9	1442.1	1436.2	1413.2	1405.5	1399.9	1399.9	1403.4	1415.2	1437.5	1444.0	1444.0	1444.0	1427.1	44.1	1444.0	1	1399.9	7
2006	1444.0	1441.9	1442.1	1436.2	1414.6	1406.7	1399.9	1400.6	1403.9	1416.8	1435.6	1444.0	1444.0	1444.0	1427.3	44.1	1444.0	1	1399.9	7
2007	1444.0	1441.9	1442.1	1436.2	1412.2	1402.7	1399.9	1399.9	1403.4	1415.2	1436.1	1444.0	1444.0	1444.0	1426.7	44.1	1444.0	1	1399.9	7
2008	1444.0	1442.0	1442.1	1436.2	1413.8	1404.0	1399.9	1399.9	1402.4	1415.2	1435.6	1444.0	1444.0	1444.0	1426.8	44.1	1444.0	1	1399.9	7
AVG	1444.0	1441.9	1440.8	1435.4	1411.2	1402.4	1399.3	1399.9	1402.0	1415.0	1436.3	1444.0	1444.0	1444.0						
RNG	0.0	0.1	4.0	4.2	8.6	10.3	6.3	1.9	4.0	3.4	2.2	0.0	0.0	0.0						
SDEV	0.0	0.0	1.3	1.3	2.4	2.6	1.5	0.3	1.5	0.6	0.8	0.0	0.0	0.0						
FMAX	1444.0	1442.0	1442.1	1436.2	1414.6	1406.7	1399.9	1400.6	1403.9	1416.8	1437.5	1444.0	1444.0	1444.0						
FMIN	1444.0	1441.9	1438.1	1432.0	1406.0	1396.4	1393.6	1398.7	1399.9	1413.4	1435.3	1444.0	1444.0	1444.0						
MXYR	1989	2004	2000	1994	2006	2006	1991	2006	2006	2006	2002	1989	1989	1989						
MNYR	1989	1989	1989	1990	1990	1990	1990	1990	1989	1996	1993	1989	1989	1989						

Figure A6.2.3 Maximum (crosses), mean (squares) and minimum (diamonds) values of the median (50 % exceedance) hydrograph of elevations, Arrow Lakes Reservoir, Regime 1 (AOS)

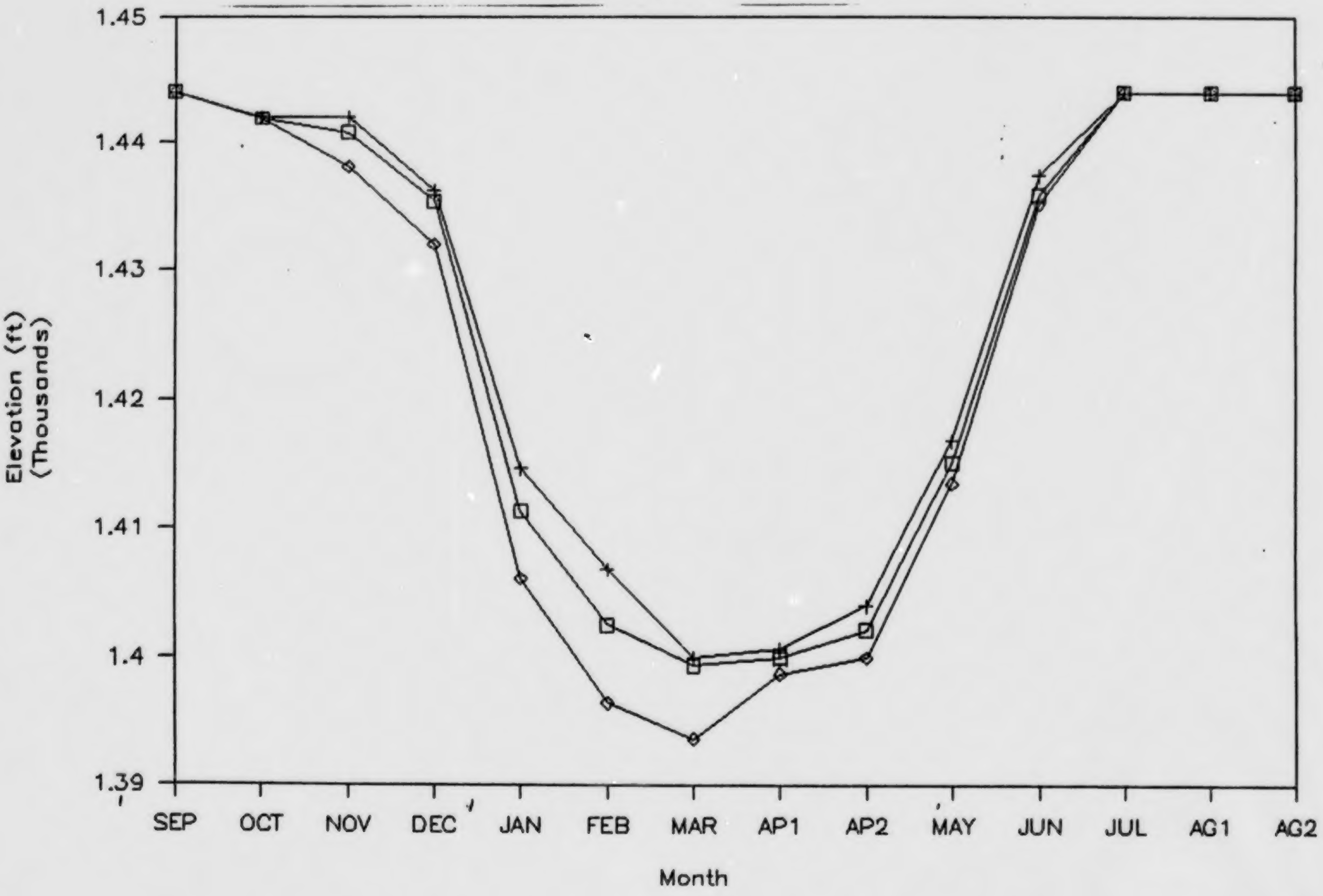
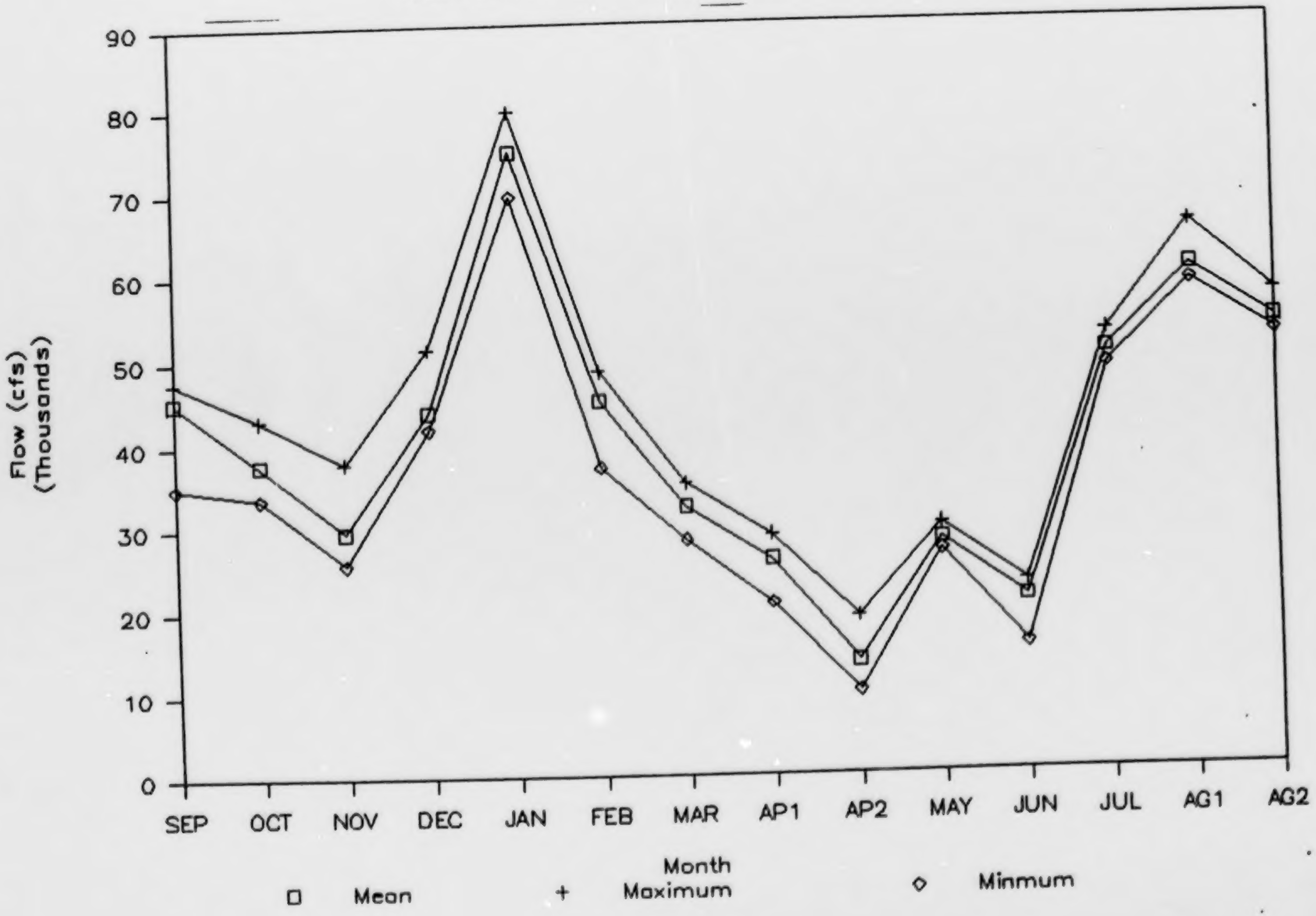


Table A6.2.4 Summary table of median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 1 (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	34978.0	33627.0	32758.0	48765.0	75729.0	36846.0	28006.0	22886.0	13235.0	27982.0	21180.0	48586.0	60493.0	52870.0	38599.9	62494.0	75729.0	5	13235.0	9
1990	42906.0	43110.0	37852.0	51275.0	71597.0	48262.0	31310.0	22886.0	18639.0	28903.0	22546.0	50253.0	63132.0	52870.0	42231.5	52958.0	71597.0	5	18639.0	9
1991	46897.0	40386.0	34908.0	46502.0	77465.0	40671.0	29581.0	22079.0	15195.0	28286.0	20986.0	51198.0	60493.0	56810.0	41180.7	62270.0	77465.0	5	15195.0	9
1992	47735.0	41494.0	34212.0	45372.0	73326.0	43546.0	28673.0	20381.0	16655.0	27325.0	19547.0	48349.0	65162.0	54162.0	40646.6	56671.0	73326.0	5	16655.0	9
1993	47125.0	40386.0	32930.0	44254.0	79546.0	45395.0	29612.0	25836.0	12138.0	27325.0	21926.0	48678.0	58273.0	54498.0	41045.8	67408.0	79546.0	5	12138.0	9
1994	47361.0	40186.0	30428.0	43452.0	75758.0	47421.0	32055.0	25835.0	11588.0	26397.0	19020.0	50628.0	58719.0	52625.0	40590.8	64170.0	75758.0	5	11588.0	9
1995	45340.0	36570.0	28729.0	42959.0	78967.0	44848.0	29131.0	23068.0	9797.0	27325.0	19332.0	48678.0	59997.0	52876.0	39562.3	69170.0	78967.0	5	9797.0	9
1996	44641.0	37541.0	27740.0	42255.0	74012.0	42248.0	33518.0	25965.0	16773.0	27325.0	19663.0	49797.0	58273.0	53388.0	39661.6	57239.0	74012.0	5	16773.0	9
1997	45186.0	35924.0	27391.0	42475.0	77344.0	43045.0	33448.0	25273.0	13506.0	29511.0	15149.0	49164.0	58778.0	53736.0	39523.6	63838.0	77344.0	5	13506.0	9
1998	43535.0	35123.0	29115.0	43710.0	78948.0	45874.0	31015.0	26934.0	13253.0	27325.0	20986.0	49084.0	58755.0	54026.0	40099.9	65695.0	78948.0	5	13253.0	9
1999	44319.0	36228.0	28167.0	42834.0	72793.0	44929.0	33244.0	24561.0	11652.0	28401.0	19476.0	48678.0	58630.0	52378.0	39390.0	61141.0	72793.0	5	11652.0	9
2000	45760.0	36588.0	27015.0	41741.0	71438.0	43039.0	34684.0	28522.0	13305.0	27417.0	21824.0	51721.0	61094.0	54563.0	39997.4	58133.0	71438.0	5	13305.0	9
2001	46653.0	38779.0	28154.0	42833.0	76990.0	47223.0	33346.0	27288.0	13397.0	27772.0	20571.0	50276.0	59871.0	53441.0	40799.6	63593.0	76990.0	5	13397.0	9
2002	46196.0	36932.0	28786.0	45560.0	76351.0	45958.0	32362.0	25758.0	12042.0	29567.0	21926.0	51492.0	58087.0	52915.0	40794.3	64309.0	76351.0	5	12042.0	9
2003	43612.0	33856.0	25708.0	41762.0	70914.0	44415.0	32363.0	25746.0	10417.0	28192.0	20141.0	50121.0	60493.0	51905.0	38780.4	60497.0	70914.0	5	10417.0	9
2004	47026.0	37727.0	27002.0	41734.0	70496.0	45670.0	34824.0	28006.0	12787.0	27325.0	22099.0	51199.0	59356.0	55492.0	40243.5	57709.0	70496.0	5	12787.0	9
2005	47502.0	38462.0	27391.0	42255.0	73228.0	46504.0	32681.0	27387.0	13820.0	26822.0	21926.0	52355.0	60389.0	53260.0	40546.2	59408.0	73228.0	5	13820.0	9
2006	46149.0	37078.0	27235.0	41806.0	69335.0	44082.0	33051.0	28369.0	11609.0	28799.0	22546.0	51473.0	58683.0	52870.0	39776.6	57726.0	69335.0	5	11609.0	9
2007	45339.0	36335.0	27391.0	42355.0	77273.0	48202.0	33379.0	27288.0	13504.0	27325.0	22362.0	51548.0	60389.0	52940.0	40714.1	63769.0	77273.0	5	13504.0	9
2008	47692.0	36642.0	26352.0	41763.0	71586.0	47223.0	34064.0	28387.0	14233.0	27325.0	20986.0	51586.0	60493.0	52940.0	40270.5	57353.0	71586.0	5	14233.0	9
AVG	45297.6	37648.7	29463.2	43783.1	74654.8	44770.1	32017.3	25622.8	13377.3	27832.4	20709.6	50243.2	59978.0	53528.3						
RNG	12757.0	9483.0	12144.0	9541.0	10211.0	11416.0	6818.0	8141.0	8842.0	3170.0	7397.0	4006.0	7075.0	4905.0						
SDEV	2836.1	2468.7	3305.0	2572.2	3162.5	2752.3	2041.4	2324.7	2162.1	855.5	1739.9	1289.7	1736.1	1147.0						
FMAX	47735.0	43110.0	37852.0	51275.0	79546.0	48262.0	34824.0	28522.0	18639.0	29567.0	22546.0	52355.0	65162.0	56810.0						
FMIN	34978.0	33627.0	25708.0	41734.0	69335.0	36846.0	28006.0	20381.0	9797.0	26397.0	15149.0	48349.0	58087.0	51905.0						
MXYR	1992	1990	1990	1990	1993	1990	2004	2000	1990	2002	1990	2005	1992	1991						
MNYR	1989	1989	2003	2004	2006	1989	1989	1992	1995	1994	1997	1992	2002	2003						

Figure A6.2.4 Maximum, mean and minimum median monthly hydrograph of outflows, Arrow Lakes Reservoir, Regime 1 (AOS)



APPENDIX 6.3

Differences
Regime 1 (AOS) Compared to Base Case (AOS)

Table A6.3.1 Summary table of differences between median (50% exceedance) elevations, Mica Reservoir, Regime 1 (AOS) - Base Case (AOS)

EAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
990	0.0	-0.5	-6.4	-11.5	-13.8	-14.0	-12.5	-11.8	-13.3	-13.9	-3.7	-8.8	-6.9	-7.1	-8.7	14.0	0.0	1	-14.0	6
991	-7.5	-5.3	-10.5	-13.6	-19.6	-21.5	-22.0	-24.4	-26.0	-23.5	-15.9	-14.3	-13.5	-12.4	-16.0	20.7	-5.3	2	-26.0	9
1992	-13.2	-13.8	-16.7	-20.9	-26.5	-27.8	-29.9	-32.4	-35.7	-26.4	-21.6	-20.2	-19.4	-19.7	-22.6	22.5	-13.2	1	-35.7	9
1993	-18.1	-19.2	-23.2	-25.8	-29.0	-30.7	-34.0	-37.4	-35.1	-29.4	-23.6	-21.2	-23.0	-25.2	-26.2	19.3	-18.1	1	-37.4	8
994	-32.4	-40.1	-44.2	-43.1	-46.5	-52.6	-57.4	-60.5	-57.7	-46.7	-39.6	-39.0	-40.8	-43.6	-45.2	28.1	-32.4	1	-60.5	8
995	-50.1	-51.4	-47.6	-49.9	-54.5	-60.1	-60.5	-61.5	-62.3	-49.2	-40.6	-38.5	-38.5	-41.2	-50.3	23.8	-38.5	12	-62.3	9
1996	-48.4	-51.4	-49.3	-50.4	-53.9	-57.3	-61.8	-62.6	-60.5	-50.9	-43.9	-38.7	-38.9	-40.9	-50.6	23.9	-38.7	12	-62.6	8
997	-49.1	-51.4	-52.0	-50.8	-54.3	-57.7	-61.4	-65.1	-61.5	-53.9	-45.0	-36.4	-37.0	-39.4	-51.1	28.7	-36.4	12	-65.1	8
998	-43.7	-45.4	-48.2	-48.1	-51.7	-52.3	-55.2	-56.9	-55.2	-47.1	-35.8	-32.2	-32.7	-35.1	-45.8	24.7	-32.2	12	-56.9	8
1999	-40.8	-43.0	-45.0	-44.7	-45.7	-47.6	-51.7	-52.9	-49.8	-41.6	-32.6	-25.9	-25.0	-27.0	-41.3	27.9	-25.0	13	-52.9	8
2000	-32.9	-36.3	-41.5	-40.6	-43.2	-42.3	-42.1	-44.4	-44.1	-33.3	-23.9	-20.1	-20.7	-21.5	-35.1	24.3	-20.1	12	-44.4	8
001	-27.7	-35.1	-38.8	-42.2	-46.6	-48.8	-51.5	-53.3	-53.3	-39.9	-33.2	-26.5	-27.9	-29.7	-39.4	26.8	-26.5	12	-53.3	8
002	-37.3	-40.9	-43.6	-45.7	-49.8	-54.4	-59.1	-61.0	-59.1	-48.1	-43.4	-34.8	-36.3	-38.3	-46.2	26.2	-34.8	12	-61.0	8
2003	-41.5	-44.0	-47.7	-47.2	-47.8	-46.2	-46.3	-48.4	-47.3	-38.2	-28.4	-24.3	-25.3	-26.4	-40.4	24.1	-24.3	12	-48.4	8
004	-34.7	-40.3	-44.6	-45.2	-45.6	-45.5	-46.1	-48.4	-46.8	-36.0	-27.4	-21.5	-23.4	-25.4	-38.2	26.9	-21.5	12	-48.4	8
005	-33.5	-39.0	-43.4	-43.1	-45.4	-48.3	-51.3	-51.7	-50.4	-41.7	-32.5	-30.0	-30.7	-31.2	-40.9	21.7	-30.0	12	-51.7	8
2006	-39.5	-43.4	-49.0	-49.4	-53.1	-57.1	-58.4	-59.6	-56.5	-45.9	-38.9	-31.9	-34.2	-36.0	-46.6	27.7	-31.9	12	-59.6	8
2007	-41.1	-47.8	-49.8	-49.0	-52.3	-55.8	-58.6	-60.3	-59.5	-50.8	-42.0	-34.6	-35.4	-36.9	-48.2	25.7	-34.6	12	-60.3	8
008	-45.5	-51.3	-52.0	-53.3	-53.7	-51.9	-54.3	-56.8	-56.9	-46.8	-38.4	-31.1	-33.1	-34.1	-47.4	25.8	-31.1	12	-56.9	9
AVG	-31.9	-35.0	-37.7	-38.7	-41.7	-43.6	-45.7	-47.5	-46.5	-38.2	-30.5	-26.5	-27.1	-28.6						
RNG	50.1	51.4	52.0	53.3	54.5	60.1	61.8	65.1	62.3	53.9	45.0	39.0	40.8	43.6						
DEV	15.8	17.3	16.5	15.5	15.5	16.4	17.5	17.9	16.9	13.8	12.8	10.5	11.0	11.8						
FMAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
FMIN	-50.1	-51.4	-52.0	-53.3	-54.5	-60.1	-61.8	-65.1	-62.3	-53.9	-45.0	-39.0	-40.8	-43.6						
XYR	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989	1989						
NYR	1995	1995	1997	2008	1995	1995	1996	1997	1995	1997	1997	1994	1994	1994						

Figure A6.3.1 Maximum, mean and minimum differences between median monthly hydrographs of elevations, Mica Reservoir, Regime 1 (AOS) - Base Case (AOS)

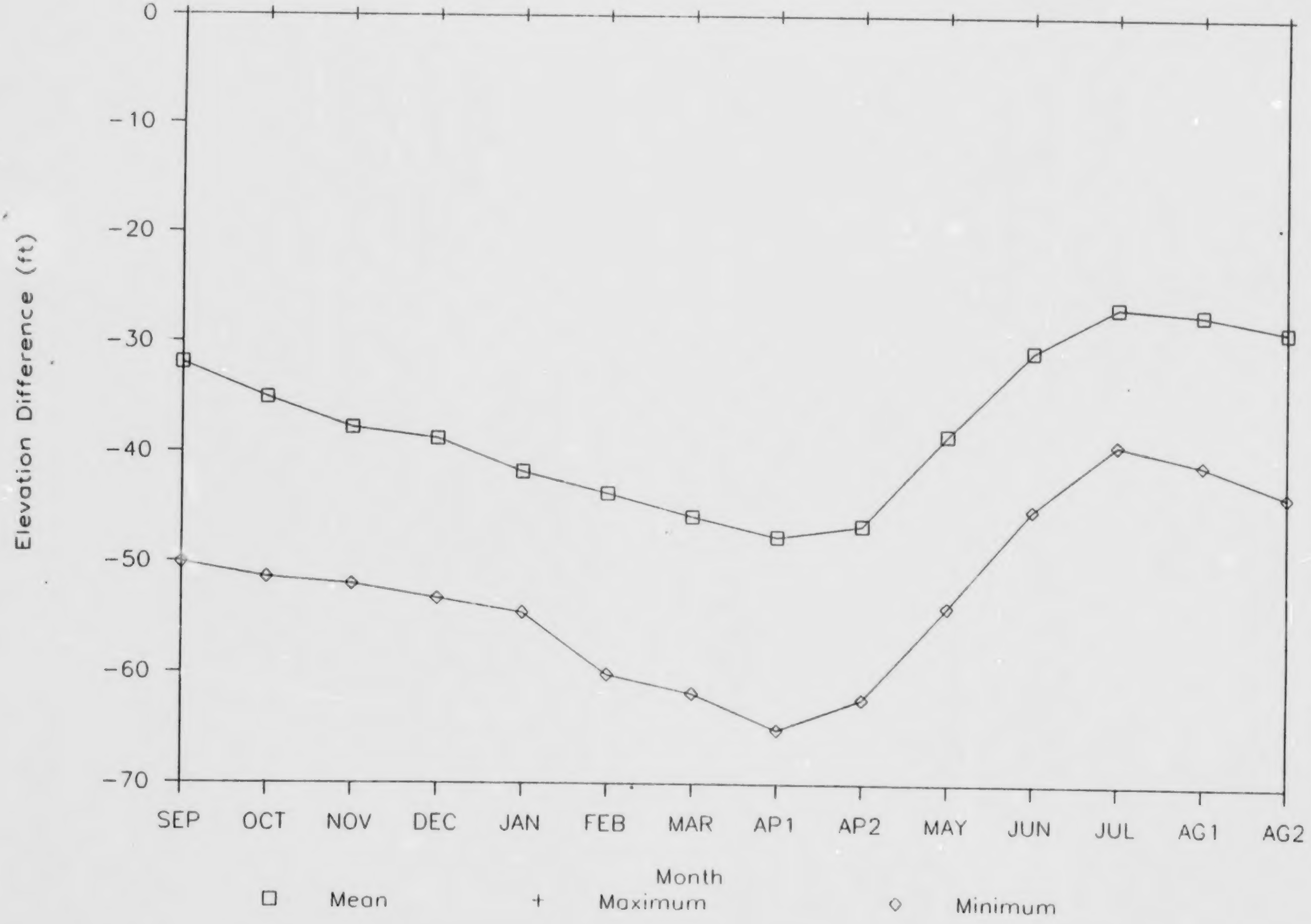


Table A6.3.2 Summary table of differences between median (50% exceedance) outflows, Mica Reservoir, Regime 1 (AOS) - Base Case (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	8527.0	7121.0	6985.0	0.0	-2266.0	0.0	0.0	0.0	0.0	0.0	-544.0	-237.0	492.0	1662.5	10793.0	8527.0	2	-2266.0	6
1991	1701.0	3917.0	4722.0	224.0	0.0	-4900.0	0.0	0.0	0.0	0.0	0.0	-2328.0	-1196.0	-470.0	208.6	9622.0	4722.0	3	-4900.0	6
1992	1.0	5166.0	4134.0	0.0	0.0	-276.0	-3083.0	0.0	0.0	0.0	-595.0	-4406.0	-532.0	-400.0	39.6	9572.0	5166.0	2	-4406.0	12
1993	0.0	4437.0	7136.0	0.0	0.0	0.0	-1431.0	-2702.0	0.0	0.0	-1997.0	-4538.0	3633.0	3409.0	481.4	11674.0	7136.0	3	-4538.0	12
1994	11718.0	9887.0	7424.0	0.0	0.0	0.0	-483.0	-4590.0	0.0	0.0	0.0	-5321.0	4195.0	2292.0	2014.5	17039.0	11718.0	1	-5321.0	12
1995	8950.0	3590.0	6334.0	0.0	0.0	0.0	-4782.0	-5000.0	0.0	0.0	0.0	-4292.0	1489.0	1822.0	746.3	13950.0	8950.0	1	-5000.0	8
1996	9013.0	5155.0	4106.0	0.0	0.0	0.0	-2319.0	-5000.0	0.0	0.0	0.0	-7546.0	3623.0	2483.0	746.8	16559.0	9013.0	1	-7546.0	12
1997	7572.0	2920.0	3873.0	0.0	0.0	0.0	-1931.0	-5000.0	0.0	0.0	-954.0	-5734.0	1592.0	1690.0	407.3	13306.0	7572.0	1	-5734.0	12
1998	5962.0	1670.0	921.0	0.0	0.0	0.0	-1527.0	-3782.0	0.0	0.0	-4519.0	-6866.0	2318.0	2144.0	-334.9	12828.0	5962.0	1	-6866.0	12
1999	7500.0	4192.0	1160.0	0.0	0.0	-2703.0	-2968.0	0.0	0.0	0.0	-1173.0	-6718.0	1004.0	103.0	-13.0	14218.0	7500.0	1	-6718.0	12
2000	10816.0	4070.0	1405.0	2436.0	0.0	-4429.0	-5804.0	-4186.0	0.0	0.0	0.0	-7186.0	3432.0	1414.0	136.5	18002.0	10816.0	1	-7186.0	12
2001	11000.0	8554.0	4311.0	0.0	0.0	0.0	-4588.0	-3506.0	0.0	0.0	-2629.0	-4709.0	3320.0	1834.0	1063.6	15709.0	11000.0	1	-4709.0	12
2002	8918.0	5652.0	3058.0	0.0	0.0	0.0	0.0	-4265.0	0.0	0.0	-1499.0	-6268.0	1708.0	1834.0	791.6	15186.0	8918.0	1	-6268.0	12
2003	5962.0	2138.0	1027.0	-3486.0	0.0	-4940.0	-6083.0	-3508.0	0.0	0.0	-600.0	-3899.0	2615.0	1112.0	-814.3	12045.0	5962.0	1	-6083.0	7
2004	11720.0	6323.0	2732.0	59.0	0.0	-5134.0	-4254.0	-1993.0	0.0	0.0	-1520.0	-5677.0	3623.0	2766.0	537.3	17397.0	11720.0	1	-5677.0	12
2005	11200.0	7306.0	4751.0	5000.0	0.0	0.0	-3728.0	-3487.0	0.0	0.0	-1209.0	-4373.0	2863.0	2870.0	1672.5	15573.0	11200.0	1	-4373.0	12
2006	11198.0	4400.0	2613.0	4427.0	0.0	0.0	-3178.0	-5000.0	0.0	0.0	0.0	-6251.0	3223.0	2390.0	1126.3	17449.0	11198.0	1	-6251.0	12
2007	8476.0	3345.0	1160.0	4974.0	0.0	0.0	-2010.0	0.0	0.0	0.0	-1759.0	-6058.0	3633.0	2331.0	925.8	14534.0	8476.0	1	-6058.0	12
2008	10776.0	3260.0	1102.0	1.0	0.0	0.0	-3796.0	-3177.0	0.0	0.0	0.0	-6037.0	2953.0	1352.0	489.2	16813.0	10776.0	1	-6037.0	12
AVG	7124.1	4725.5	3454.5	1031.0	0.0	-1232.4	-2598.3	-2759.8	0.0	0.0	-922.7	-4937.5	2162.9	1573.4						
RNG	11720.0	9887.0	7424.0	10471.0	0.0	5134.0	6083.0	5000.0	0.0	0.0	4519.0	7546.0	5391.0	3879.0						
SDEV	4381.9	2457.2	2317.3	2460.3	0.0	2006.9	1948.9	2011.5	0.0	0.0	1178.9	2037.0	1613.2	1118.2						
FMAX	11720.0	9887.0	7424.0	6985.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4195.0	3409.0						
FMIN	0.0	0.0	0.0	-3486.0	0.0	-5134.0	-6083.0	-5000.0	0.0	0.0	-4519.0	-7546.0	-1196.0	-470.0						
MXYR	2004	1994	1994	1990	1963	1989	1989	1989	1989	1989	1989	1989	1994	1993						
MNYR	1989	1989	1989	2003	1989	2004	2003	1995	1989	1989	1998	1996	1991	1991						

Figure A6.3.2 Maximum, mean and minimum differences between median monthly hydrographs for outflows, Mica Reservoir, Regime 1 (AOS) - Base Case (AOS)

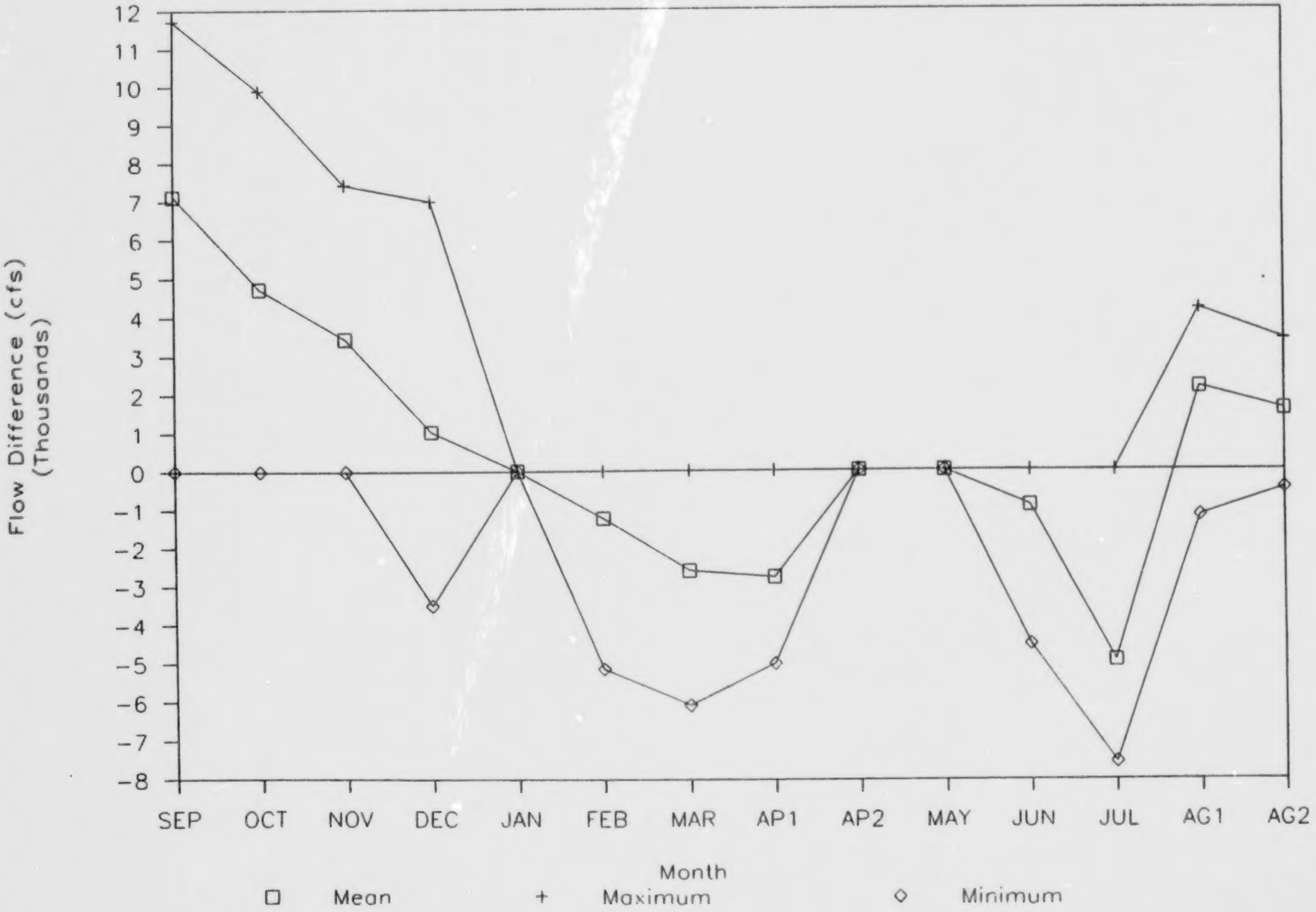


Table A6.3.3 Summary table of differences between median (50% exceedance) elevations, Arrow Lakes Reservoir, Regime 1 (AOS) - Base Case (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	NT	MIN	NT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	1
1990	0.0	0.0	0.0	0.4	-0.6	0.0	-2.3	-1.2	0.0	0.0	0.3	0.0	0.0	0.0	-0.2	2.7	0.4	4	-2.3	7
1991	0.0	0.0	-0.1	0.7	0.2	1.2	1.7	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.4	1.8	1.7	7	-0.1	3
1992	0.0	0.0	0.1	0.4	1.0	0.1	0.9	0.0	0.0	-0.6	0.0	0.0	0.0	0.0	0.2	1.6	1.0	5	-0.6	10
1993	0.1	0.0	0.3	0.4	0.6	-0.1	0.4	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.2	0.8	0.7	9	-0.1	6
1994	0.3	1.5	0.6	0.0	0.9	0.7	0.0	0.0	0.3	0.0	0.5	0.0	0.0	0.0	0.4	1.5	1.5	2	0.0	4
1995	0.5	1.4	1.1	0.0	0.5	1.2	0.1	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.5	2.5	2.5	9	0.0	4
1996	0.4	1.0	0.4	0.0	1.1	0.6	0.0	0.0	0.6	0.4	0.2	0.0	0.0	0.0	0.4	1.1	1.1	5	0.0	4
1997	0.3	0.4	0.5	0.0	0.4	0.8	-0.0	0.0	0.2	1.4	-0.3	0.0	0.0	0.0	0.3	1.7	1.4	10	-0.3	11
1998	0.3	0.9	0.0	-0.1	0.5	0.1	0.3	0.0	2.7	0.0	1.7	0.0	0.0	0.0	0.4	2.8	2.7	9	-0.1	4
1999	0.2	0.0	0.2	0.2	0.4	-0.1	0.0	0.0	0.1	-0.2	-0.3	0.0	0.0	0.0	0.0	0.7	0.4	5	-0.3	11
2000	0.1	0.0	0.5	0.0	0.5	0.6	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.2	1.6	1.6	9	0.0	2
2001	0.3	0.7	0.9	0.0	0.0	0.5	0.0	0.0	1.8	0.0	0.7	0.0	0.0	0.0	0.3	1.8	1.8	9	0.0	4
2002	0.2	0.6	0.1	0.3	0.7	1.6	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.3	1.6	1.6	6	0.0	7
2003	0.2	0.3	0.8	0.0	0.4	0.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.8	0.8	3	0.0	4
2004	0.2	0.1	0.5	0.0	0.3	0.1	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.5	3	0.0	4
2005	0.2	0.2	0.5	0.0	0.1	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.5	3	0.0	4
2006	0.2	0.0	0.3	0.0	0.8	0.0	0.0	0.7	0.0	1.5	0.0	0.0	0.0	0.0	0.3	1.5	1.5	10	0.0	2
2007	0.2	0.0	0.5	0.0	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.1	1.1	5	0.0	2
2008	0.1	0.2	0.0	0.0	0.4	0.4	0.5	0.0	0.9	0.0	0.1	0.0	0.0	0.0	0.2	0.9	0.9	9	0.0	3
AVG	0.2	0.4	0.4	0.1	0.5	0.5	0.1	0.0	0.6	0.1	0.2	0.0	0.0	0.0						
RNG	0.5	1.5	1.2	0.8	1.7	1.7	4.0	1.9	2.7	2.1	2.0	0.0	0.0	0.0						
SDEV	0.1	0.5	0.3	0.2	0.4	0.5	0.7	0.3	0.9	0.5	0.5	0.0	0.0	0.0						
FMAX	0.5	1.5	1.1	0.7	1.1	1.6	1.7	0.7	2.7	1.5	1.7	0.0	0.0	0.0						
FMIN	0.0	0.0	-0.1	-0.1	-0.6	-0.1	-2.3	-1.2	0.0	-0.6	-0.3	0.0	0.0	0.0						
MXYR	1995	1994	1995	1991	1996	2002	1991	2006	1998	2006	1998	1989	1989	1989						
MNYR	1989	1989	1991	1998	1990	1993	1990	1990	1989	1992	1997	1989	1989	1989						

Figure A6.3.3 Maximum, mean and minimum differences between median monthly hydrographs of elevations, Arrow Lakes Reservoir, Regime 1 (AOS) - Base Case (AOS)

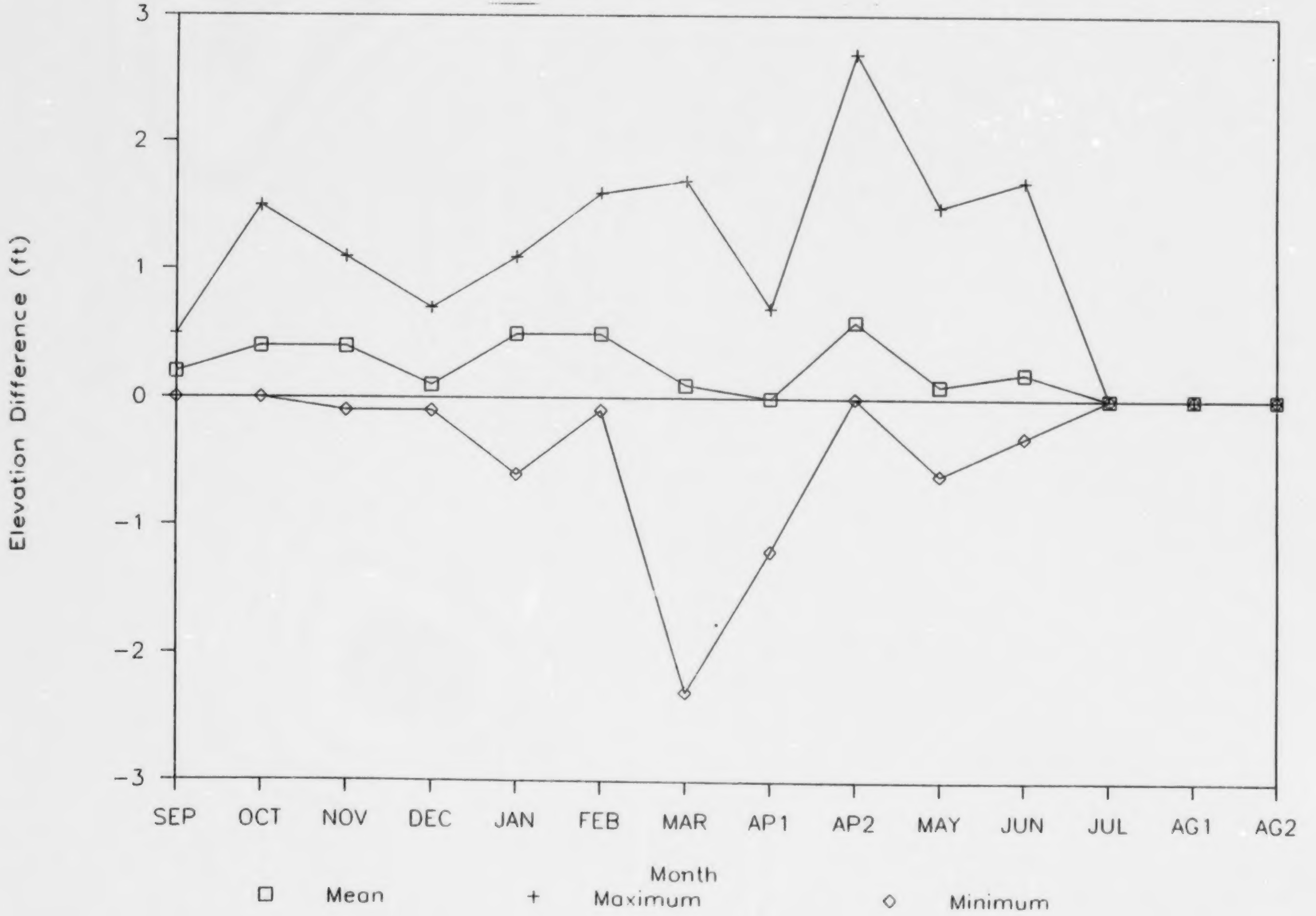
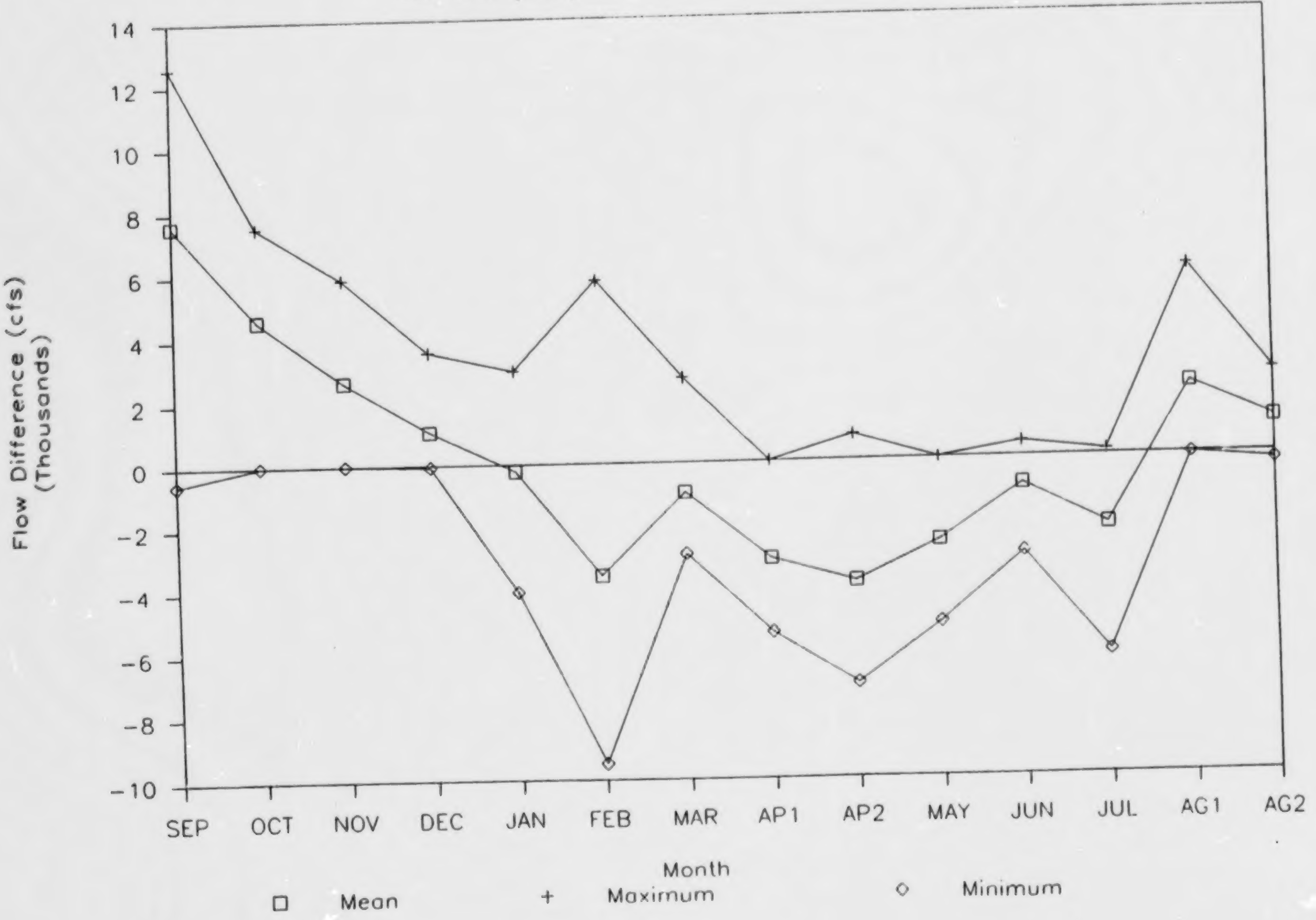


Table A6.3.4 Summary table of differences between median (50% exceedance) outflows, Arrow Lakes Reservoir, Regime 1 (AOS) - Base Case (AOS)

YEAR	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	AVG	RNG	MAX	MT	MIN	MT
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.0	0.0	0.0	0.0	4.5	54.0	54.0	11	0.0	1
1990	0.0	7514.0	5852.0	3553.0	988.0	5751.0	2658.0	0.0	793.0	0.0	-110.0	96.0	0.0	-233.0	2215.2	7747.0	7514.0	2	-233.0	14
1991	1111.0	4365.0	3965.0	900.0	2939.0	-797.0	-757.0	-762.0	3.0	-617.0	-855.0	-1899.0	0.0	828.0	699.1	6264.0	4365.0	2	-1899.0	12
1992	618.0	3622.0	4095.0	2350.0	1082.0	1608.0	144.0	-2453.0	-1142.0	-1578.0	-1193.0	-2646.0	-10.0	118.0	529.9	6741.0	4095.0	3	-2646.0	12
1993	-557.0	2487.0	4351.0	2135.0	1017.0	1178.0	-486.0	-608.0	-1146.0	-1230.0	-380.0	-2479.0	3644.0	1900.0	660.9	6830.0	4351.0	3	-2479.0	12
1994	10387.0	6927.0	3907.0	1647.0	-336.0	767.0	411.0	-3441.0	-4871.0	-3365.0	452.0	-885.0	4090.0	1343.0	1539.4	15258.0	10387.0	1	-4871.0	9
1995	8885.0	3796.0	2307.0	971.0	-691.0	-1312.0	-2826.0	-5402.0	-7046.0	-2486.0	-144.0	-2117.0	3320.0	1079.0	196.5	15931.0	8885.0	1	-7046.0	9
1996	8414.0	5019.0	1605.0	492.0	2505.0	-9473.0	-1200.0	-4603.0	-2714.0	-4772.0	187.0	-6174.0	3644.0	1111.0	-389.8	17887.0	8414.0	1	-9473.0	6
1997	8882.0	2551.0	839.0	472.0	1267.0	-8676.0	517.0	-4213.0	-4340.0	-2695.0	-3017.0	-1993.0	175.0	866.0	-467.4	17558.0	8882.0	1	-8676.0	6
1998	7515.0	2485.0	1724.0	1240.0	881.0	-5847.0	-1402.0	-2552.0	-4593.0	-5184.0	-1320.0	-1711.0	1493.0	2376.0	-271.4	13362.0	7515.0	1	-5847.0	6
1999	8163.0	4051.0	1938.0	546.0	-1806.0	-6559.0	-1474.0	-4925.0	-5695.0	-2762.0	-507.0	-2479.0	138.0	736.0	-480.2	14722.0	8163.0	1	-6559.0	6
2000	11032.0	4934.0	1699.0	7.0	-3421.0	-9490.0	-1116.0	-4348.0	-4572.0	-3731.0	-2462.0	-4250.0	2409.0	1077.0	-792.9	20522.0	11032.0	1	-9490.0	6
2001	11582.0	7179.0	2264.0	1130.0	60.0	-4498.0	-1372.0	-4509.0	-4480.0	-2005.0	-711.0	-881.0	5242.0	2046.0	991.5	16091.0	11582.0	1	-4509.0	8
2002	9993.0	4674.0	2047.0	2712.0	212.0	-147.0	-64.0	-3728.0	-5305.0	-1022.0	-603.0	-1162.0	3628.0	1285.0	1215.0	15298.0	9993.0	1	-5305.0	9
2003	8886.0	2577.0	1245.0	-48.0	-4034.0	-7410.0	-2898.0	-3740.0	-6930.0	-4646.0	-2165.0	-1300.0	2298.0	375.0	-1149.3	16296.0	8886.0	1	-7410.0	6
2004	12106.0	6266.0	3148.0	107.0	-2464.0	-6051.0	-2367.0	-4864.0	-5090.0	-2799.0	-1419.0	-4772.0	4017.0	2622.0	8.1	18157.0	12106.0	1	-6051.0	6
2005	11687.0	7278.0	3030.0	1055.0	-679.0	-5217.0	-2037.0	-3897.0	-5280.0	-3440.0	-152.0	-158.0	5930.0	1618.0	879.4	16967.0	11687.0	1	-5280.0	9
2006	11341.0	5922.0	4214.0	912.0	435.0	-5805.0	-2016.0	-4329.0	-6268.0	-3351.0	-2117.0	135.0	2331.0	1228.0	512.6	17609.0	11341.0	1	-6268.0	9
2007	9218.0	4738.0	2307.0	592.0	-794.0	-3519.0	-1092.0	-2198.0	-4342.0	-3364.0	-167.0	-4586.0	1706.0	1658.0	145.4	13804.0	9218.0	1	-4586.0	12
2008	12571.0	5276.0	2180.0	228.0	-1509.0	-5306.0	-1671.0	-1099.0	-3644.0	-3280.0	-804.0	-4263.0	778.0	250.0	130.4	17877.0	12571.0	1	-5306.0	6

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2
AVG	7591.7	4583.0	2635.9	1050.1	-217.4	-3540.1	-952.4	-3083.6	-3833.1	-2616.4	-871.7	-2176.2	2241.6	1114.2
RNG	13128.0	7514.0	5852.0	3601.0	6973.0	15241.0	5556.0	5402.0	7839.0	5184.0	3469.0	6309.0	5940.0	2855.0
SDEV	4578.6	1965.0	1413.9	984.4	1792.3	4198.0	1319.6	1751.3	2349.1	1505.4	954.0	1811.8	1892.7	782.3
FMAX	12571.0	7514.0	5852.0	3553.0	2939.0	5751.0	2658.0	0.0	793.0	0.0	452.0	135.0	5930.0	2622.0
FMIN	-557.0	0.0	0.0	-48.0	-4034.0	-9490.0	-2898.0	-5402.0	-7046.0	-5184.0	-3017.0	-6174.0	-10.0	-233.0
MXYR	2008	1990	1990	1990	1991	1990	1990	1989	1990	1989	1994	2006	2005	2004
MNYR	1993	1989	1989	2003	2003	2000	2003	1995	1995	1998	1997	1996	1992	1990

Figure A6.3.4 Maximum, mean and minimum differences between median monthly hydrographs for outflows, Arrow Lakes Reservoir, Regime 1 (AOS) - Base Case (AOS)



APPENDIX 7

Medium Energy Load Scenario
Summary Hydrographs
1989 - 2008

7.1 Base Case (Medium Load)
7.2 Regime 1 (Medium Load)
7.3 Regime 2 (Medium Load)

APPENDIX 7.1

Base Case (Medium Load)

Figure A7.1.1 Elevations at Mica Reservoir, Base Case (Medium Load): September 1989 - August 1992

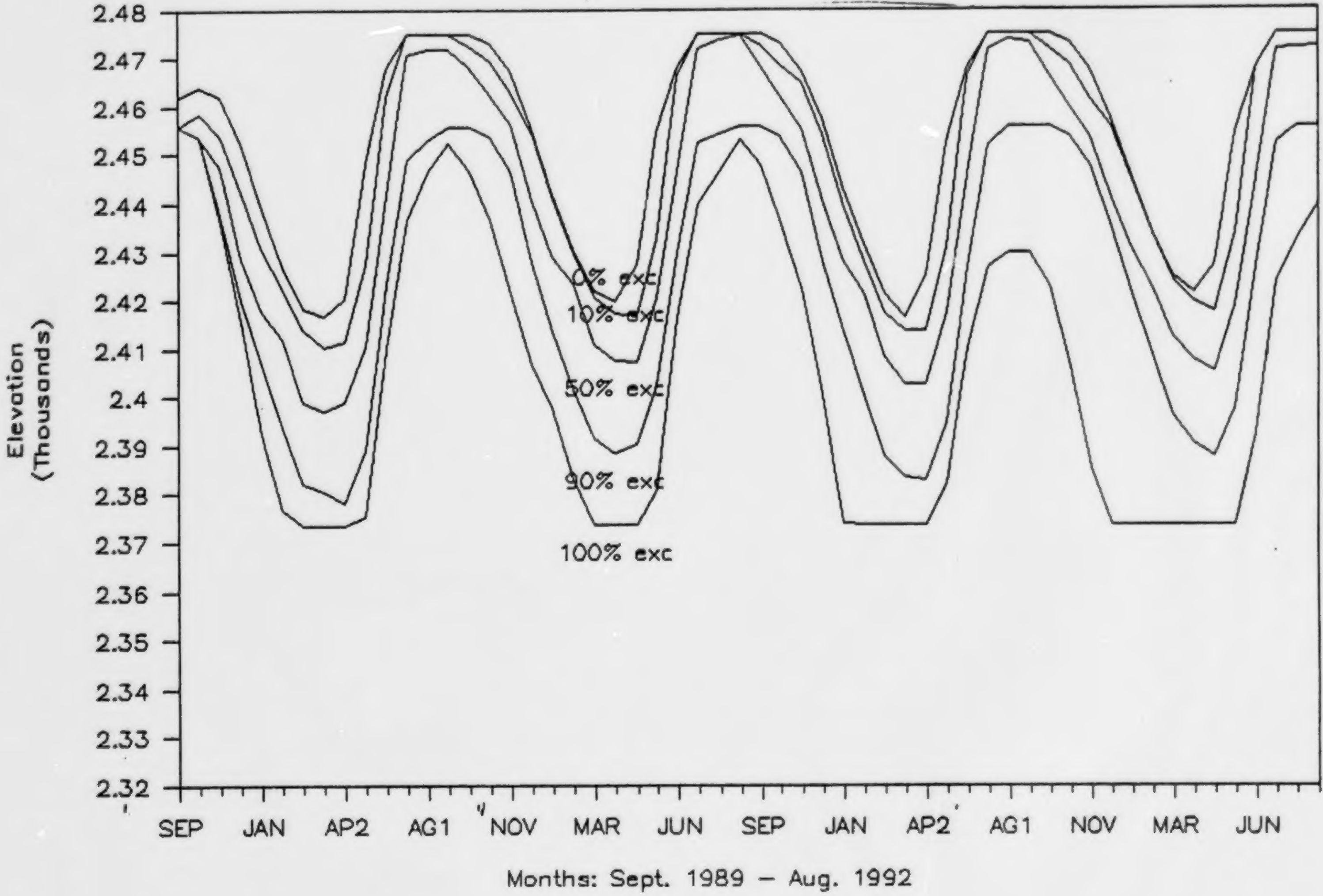


Figure A7.1.2 Elevations at Mica Reservoir, Base Case (Medium Load): September 1993 - August 1996

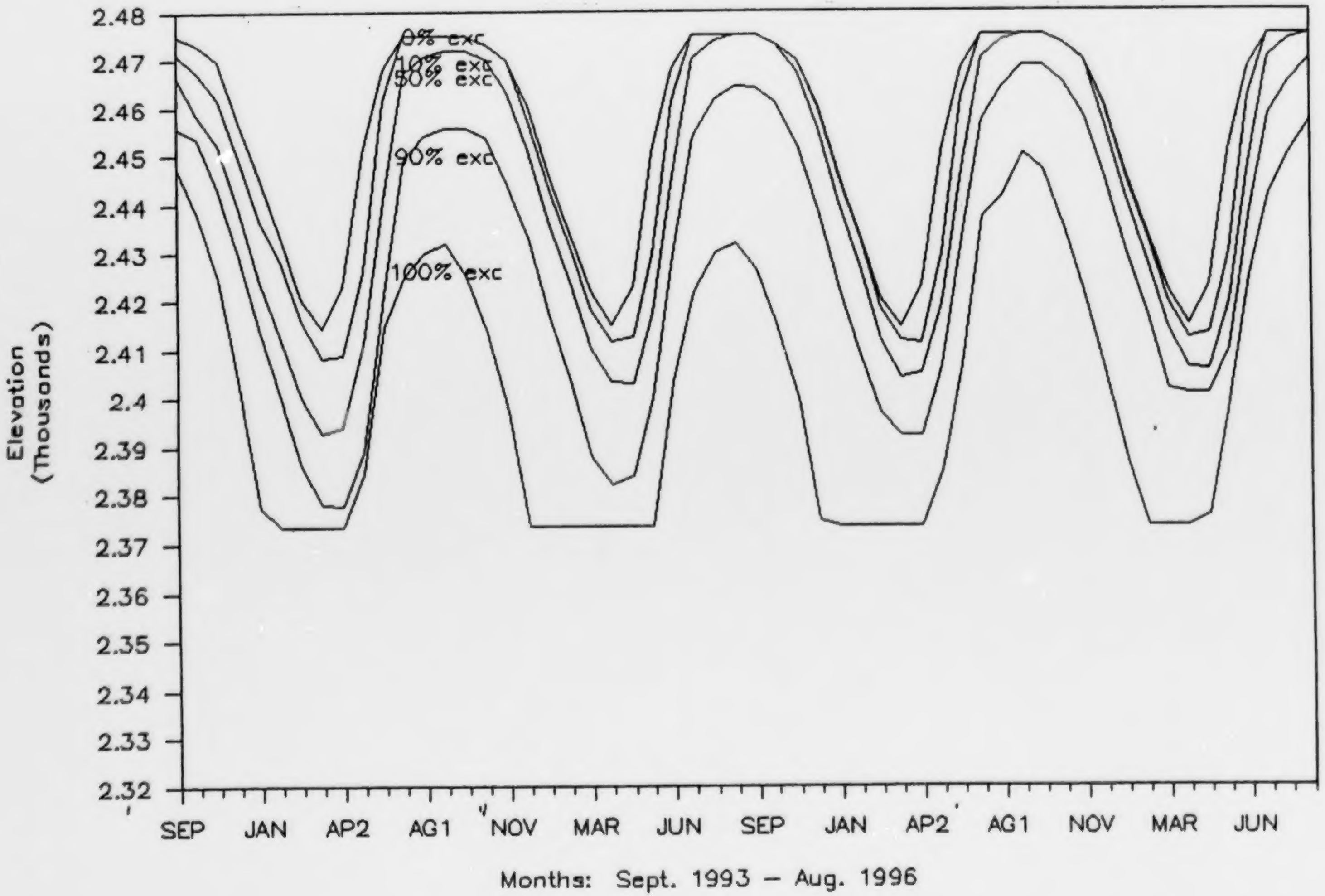


Figure A7.1.3 Elevations at Mica Reservoir, Base Case (Medium Load): September 1997 - August 2000

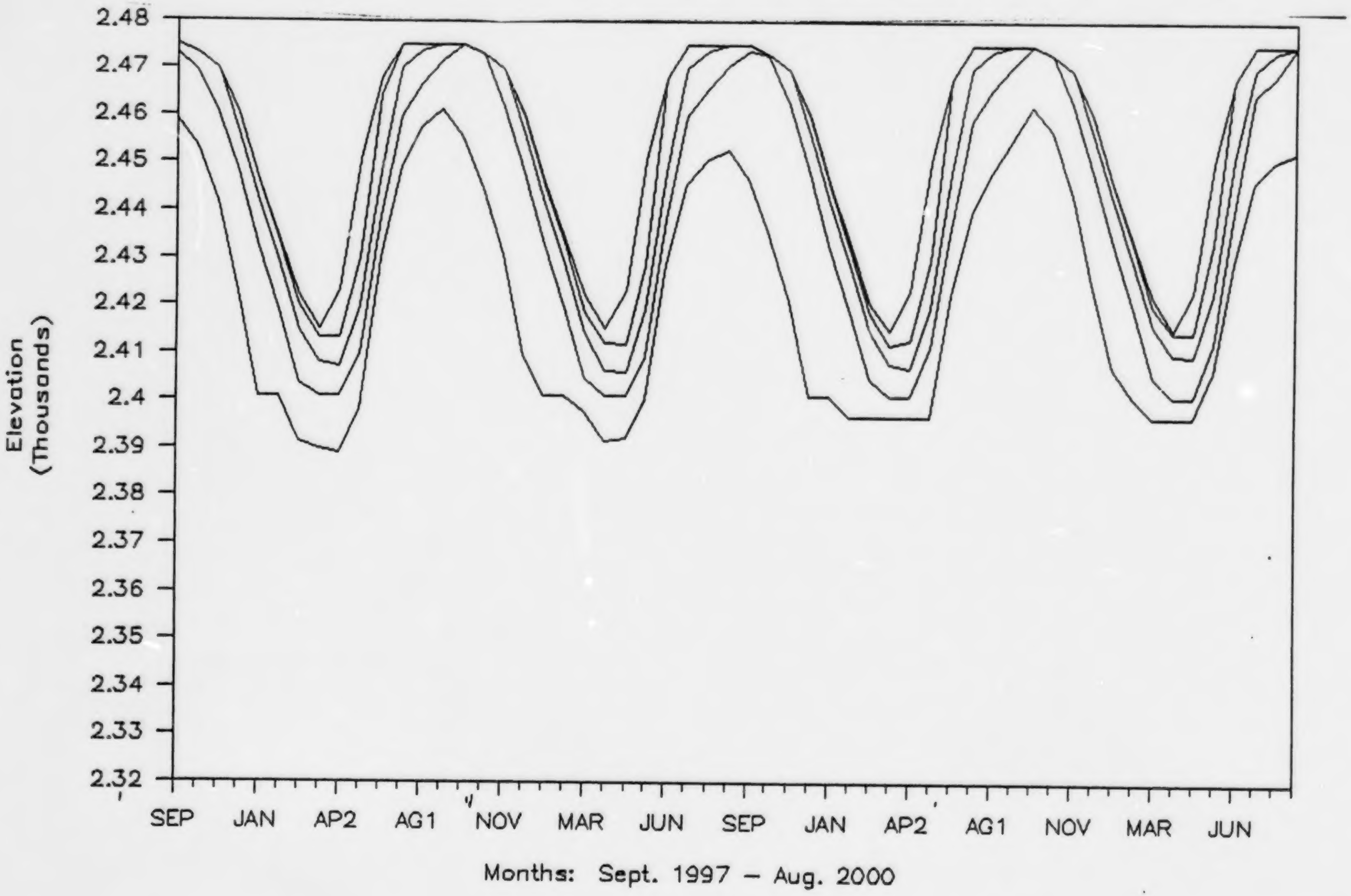


Figure A7.1.4 Elevations at Mica Reservoir, Base Case (Medium Load): September 2001 - August 2004

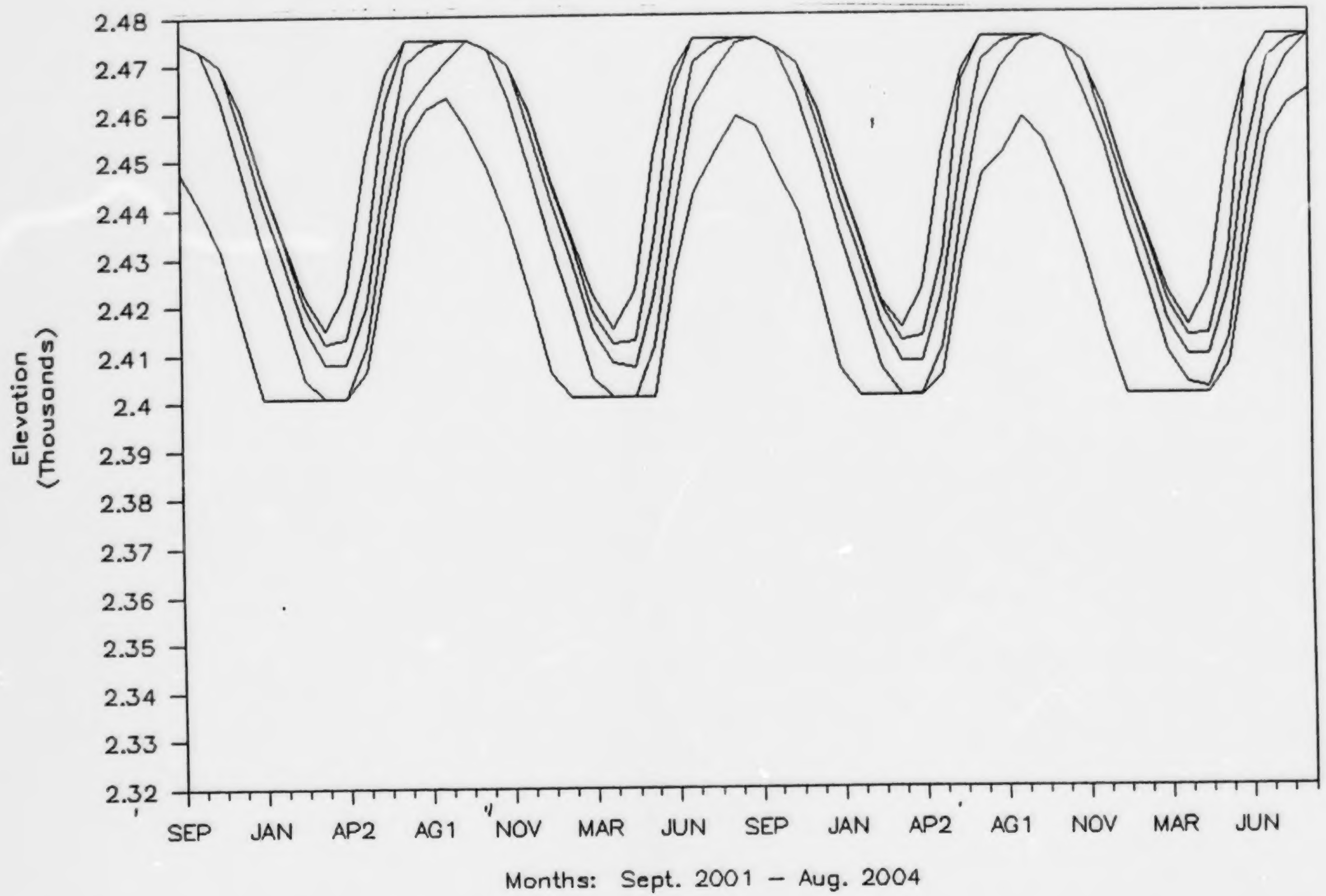


Figure A7.1.5 Elevations at Mica Reservoir, Base Case (Medium Load): September 2005 - August 2008

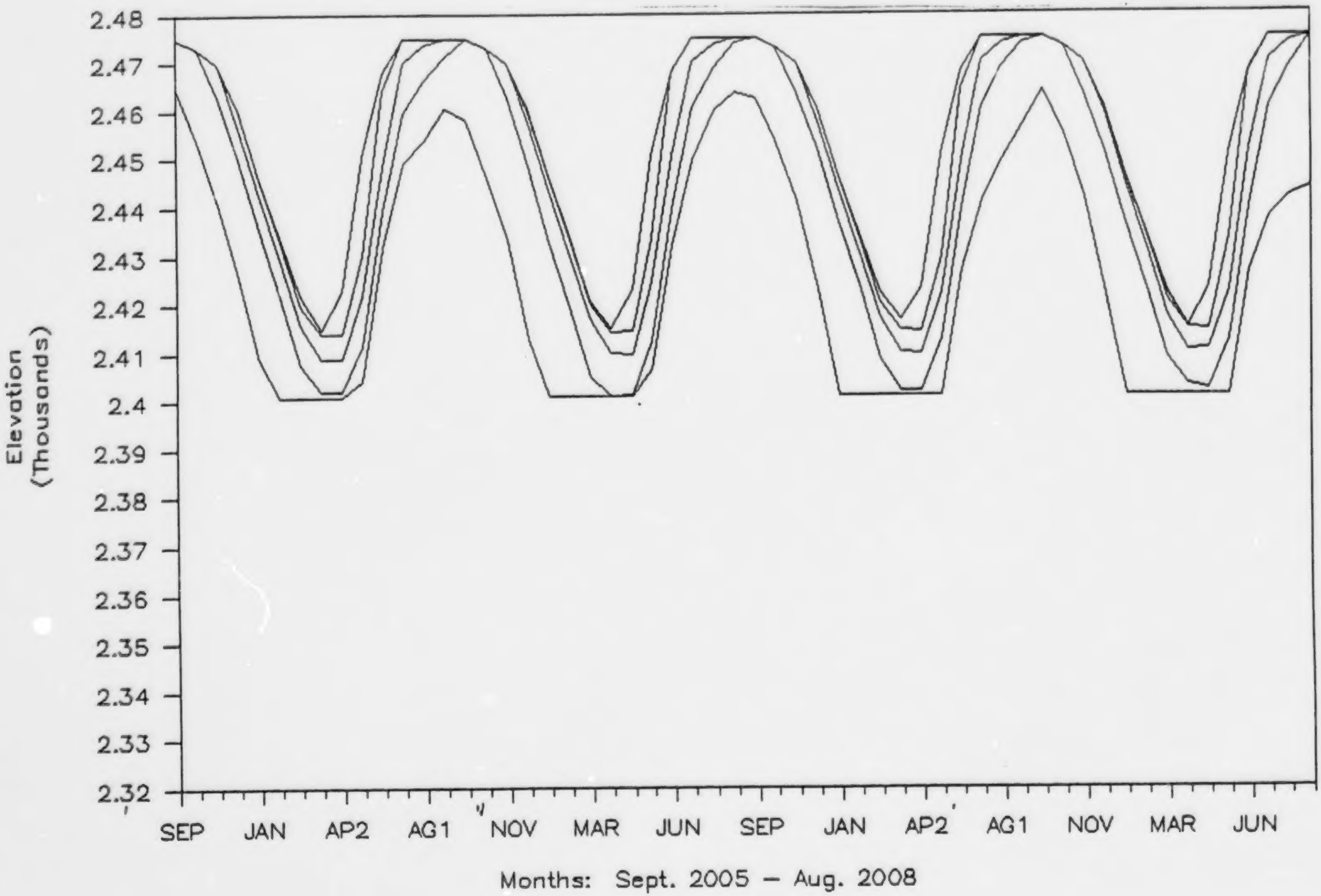


Figure A7.1.6 Flows at Mica Reservoir, Base Case (Medium Load): September 1989 - August 1992

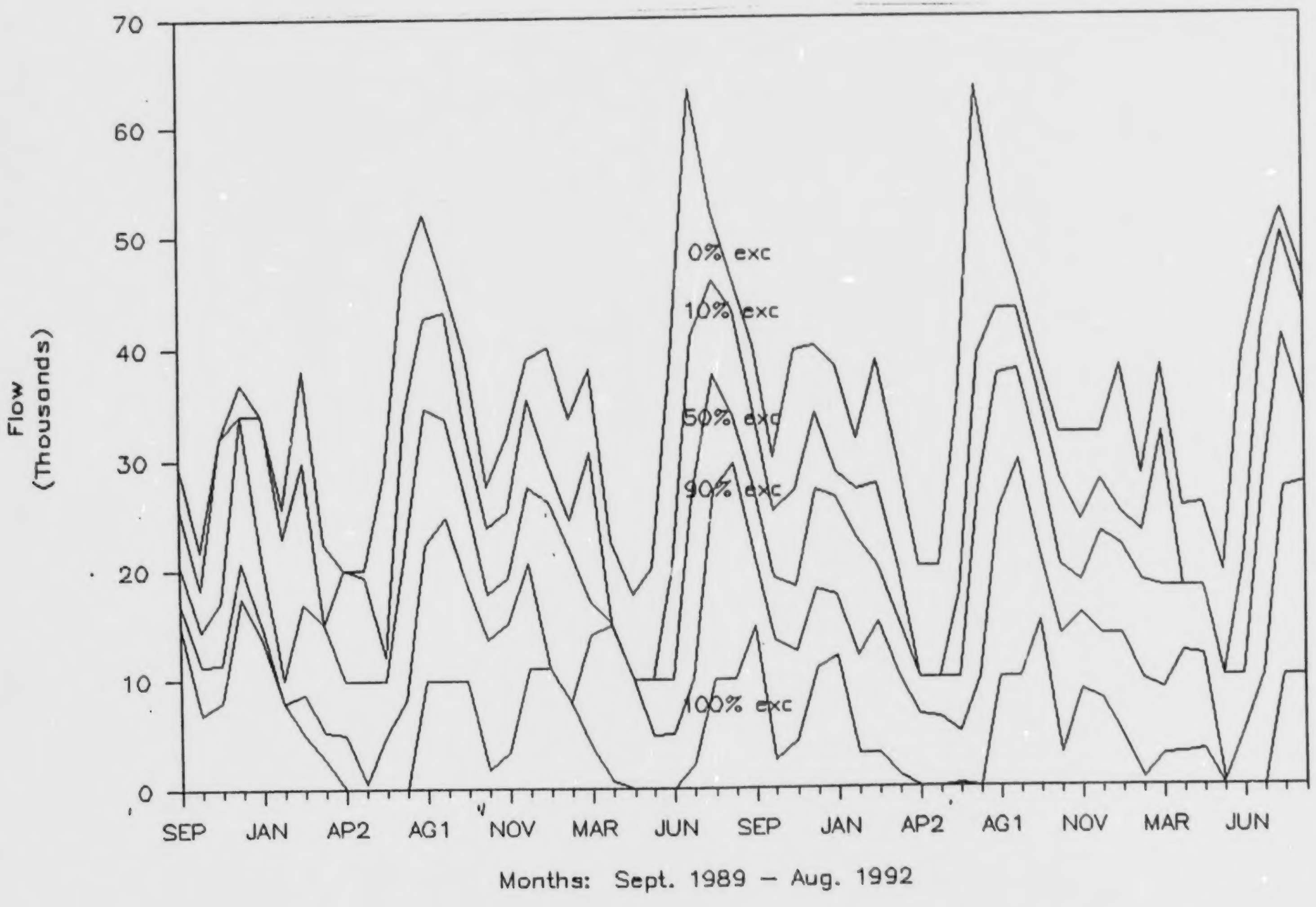


Figure A7.1.7 Flows at Mica Reservoir, Base Case (Medium Load): September 1993 - August 1996

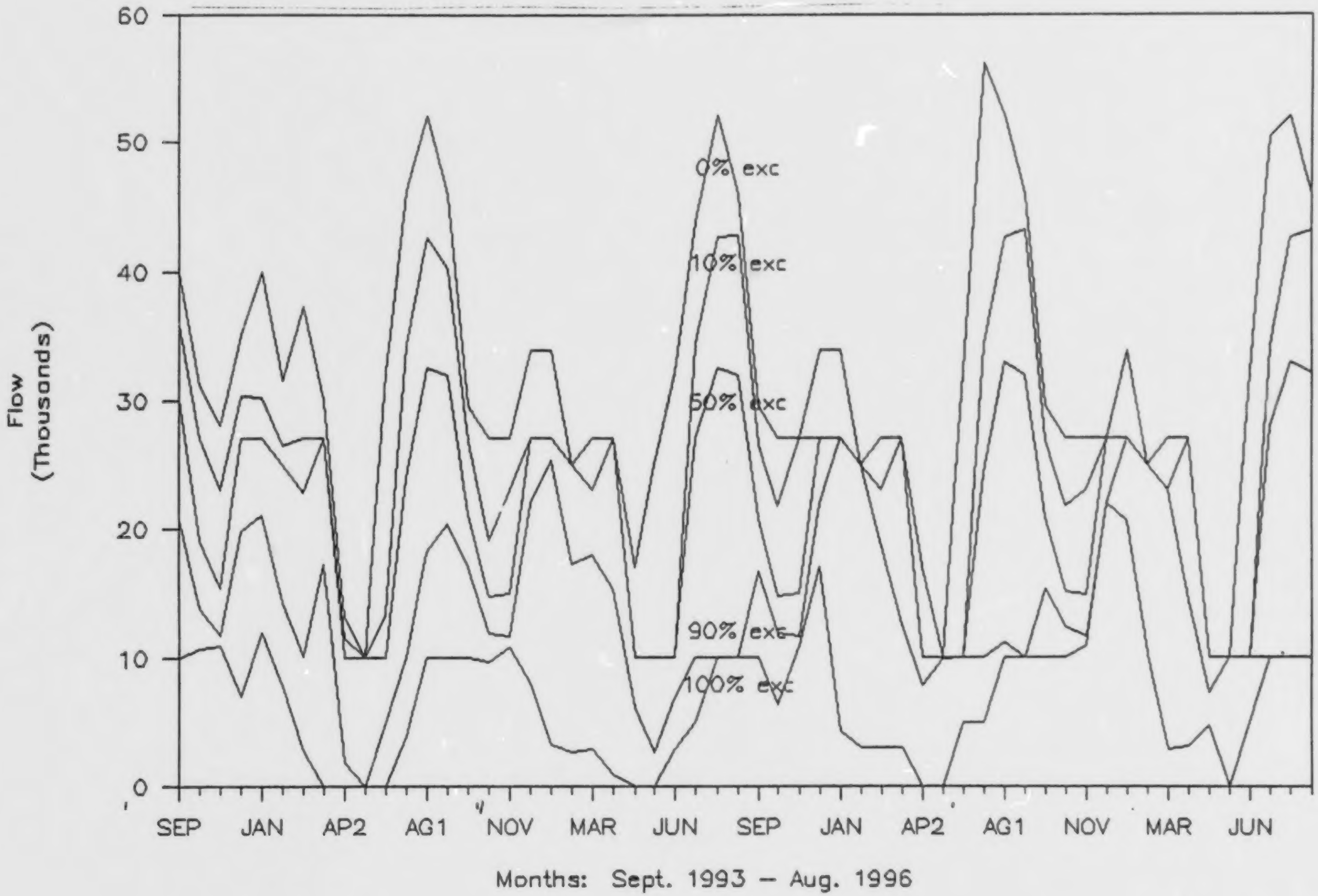


Figure A7.1.7 Flows at Mica Reservoir, Base Case (Medium Load): September 1993 - August 1996

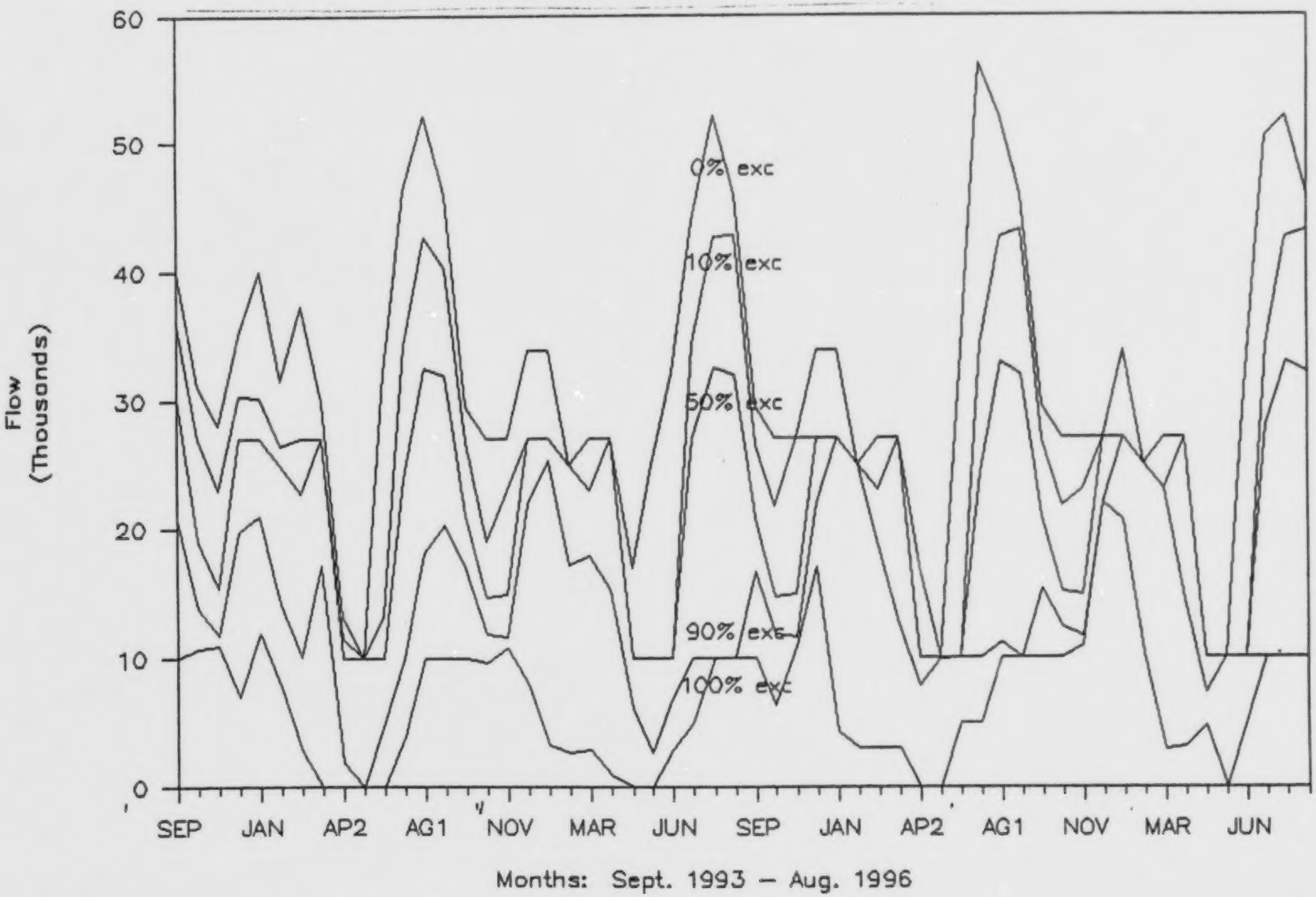


Figure A7.1.9 Flows at Mica Reservoir, Base Case (Medium Load): September 2001 - August 2004

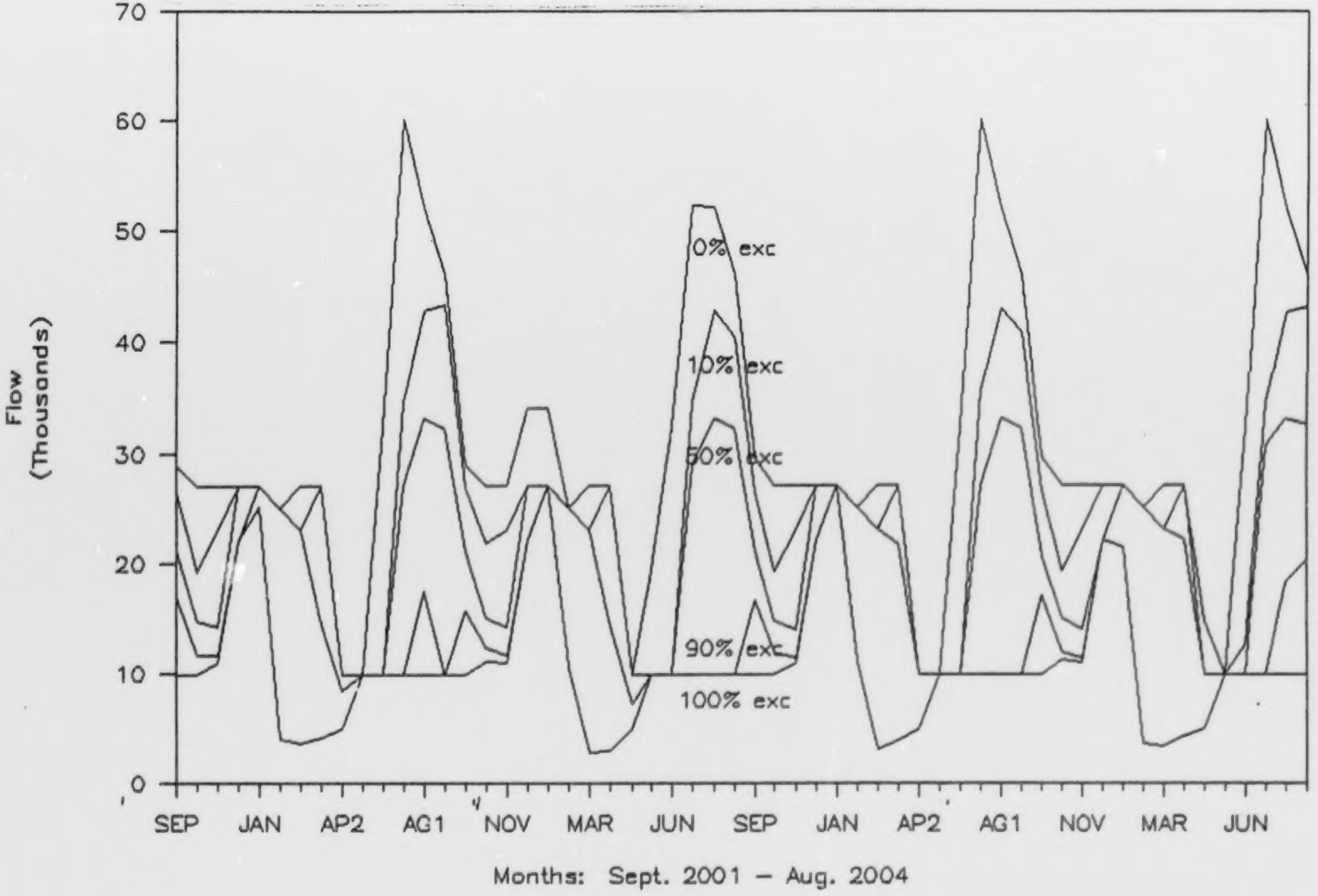


Figure A7.1.10 Flows at Mica Reservoir, Base Case (Medium Load): September 2005 - August 2008

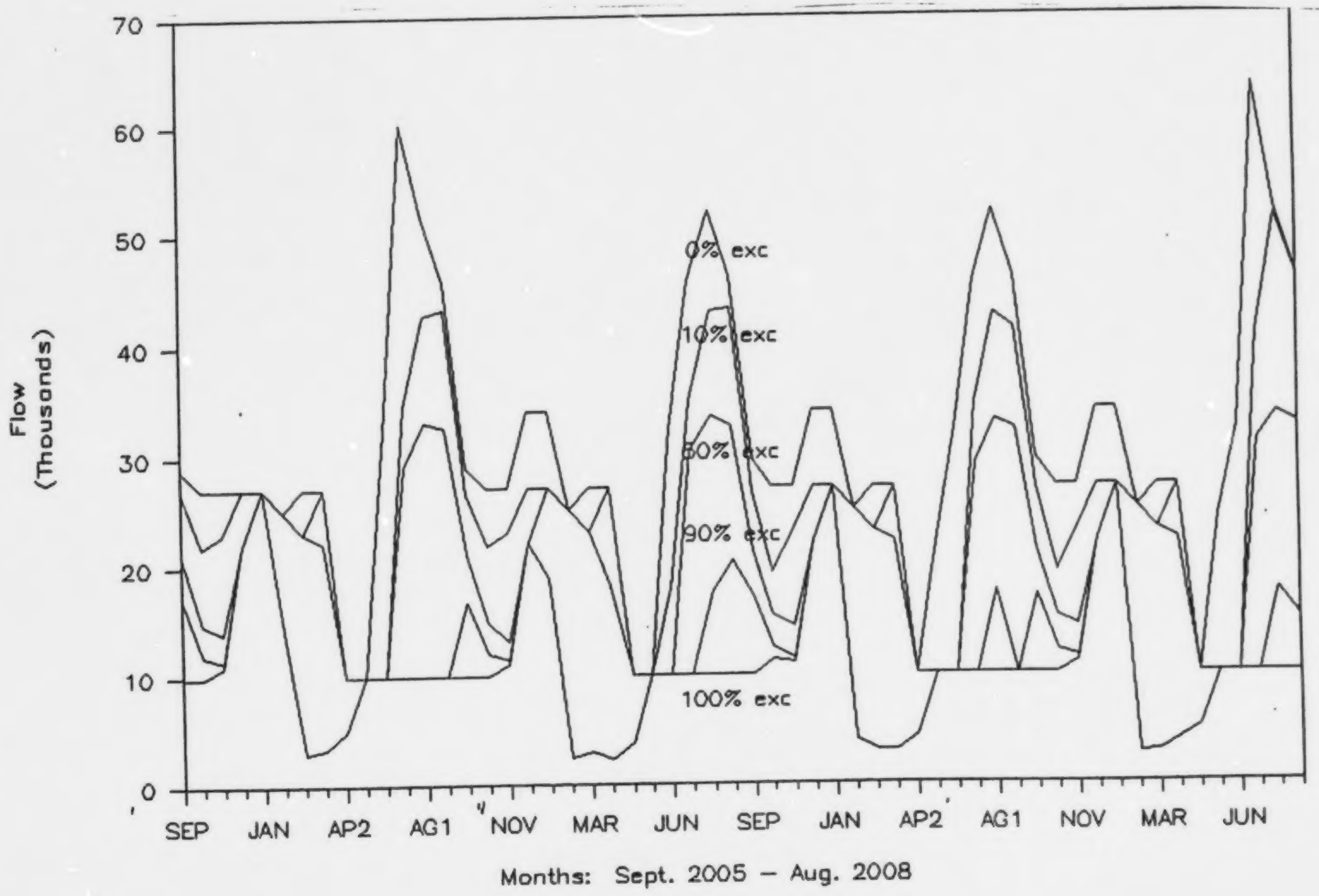


Figure A7.1.11 Elevations at Arrow Lakes Reservoir, Base Case (Medium Load): September 1989 - August 1992

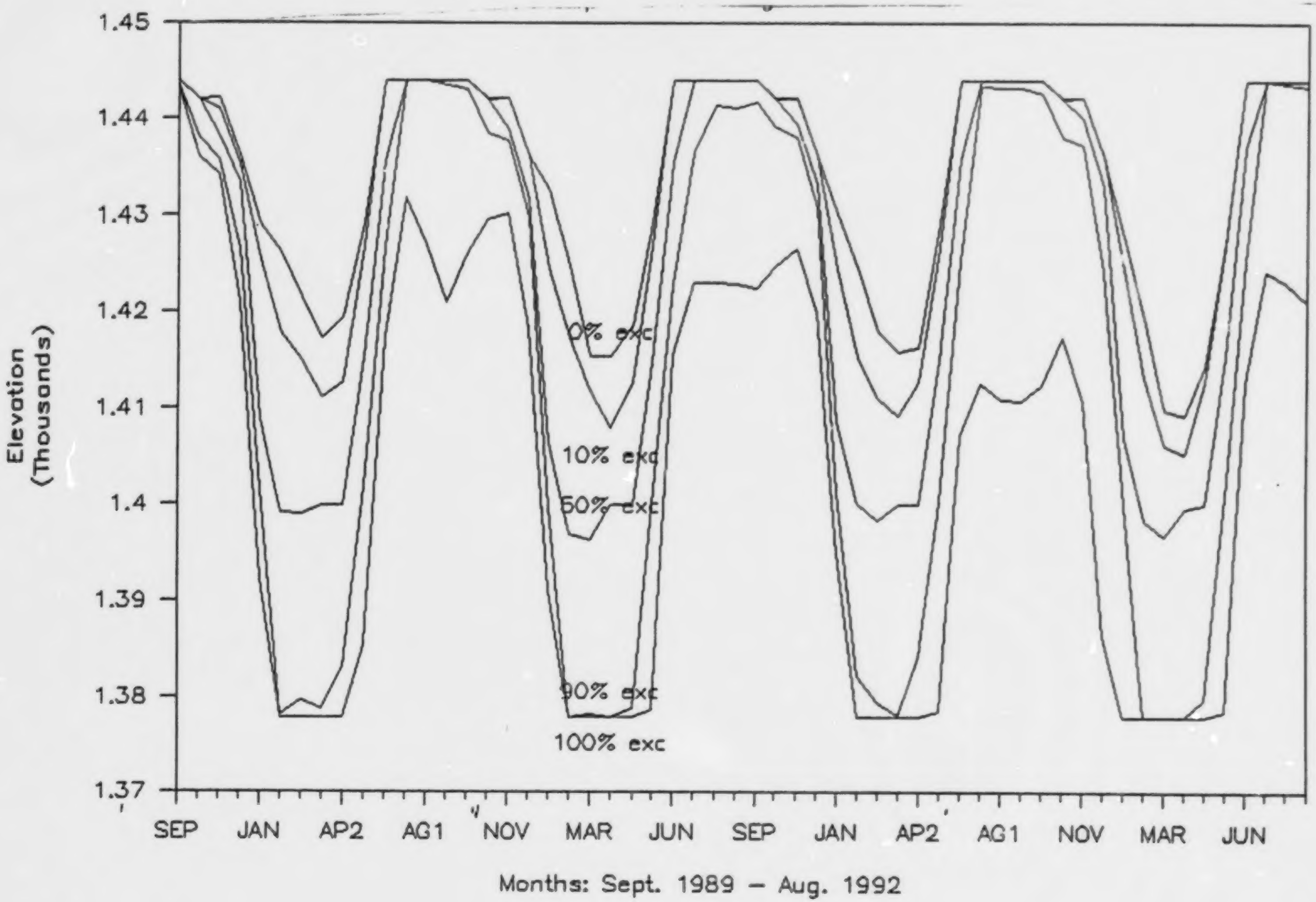


Figure A7.1.12 Elevations at Arrow Lakes Reservoir, Base Case (Medium Load): September 1993 - August 1996

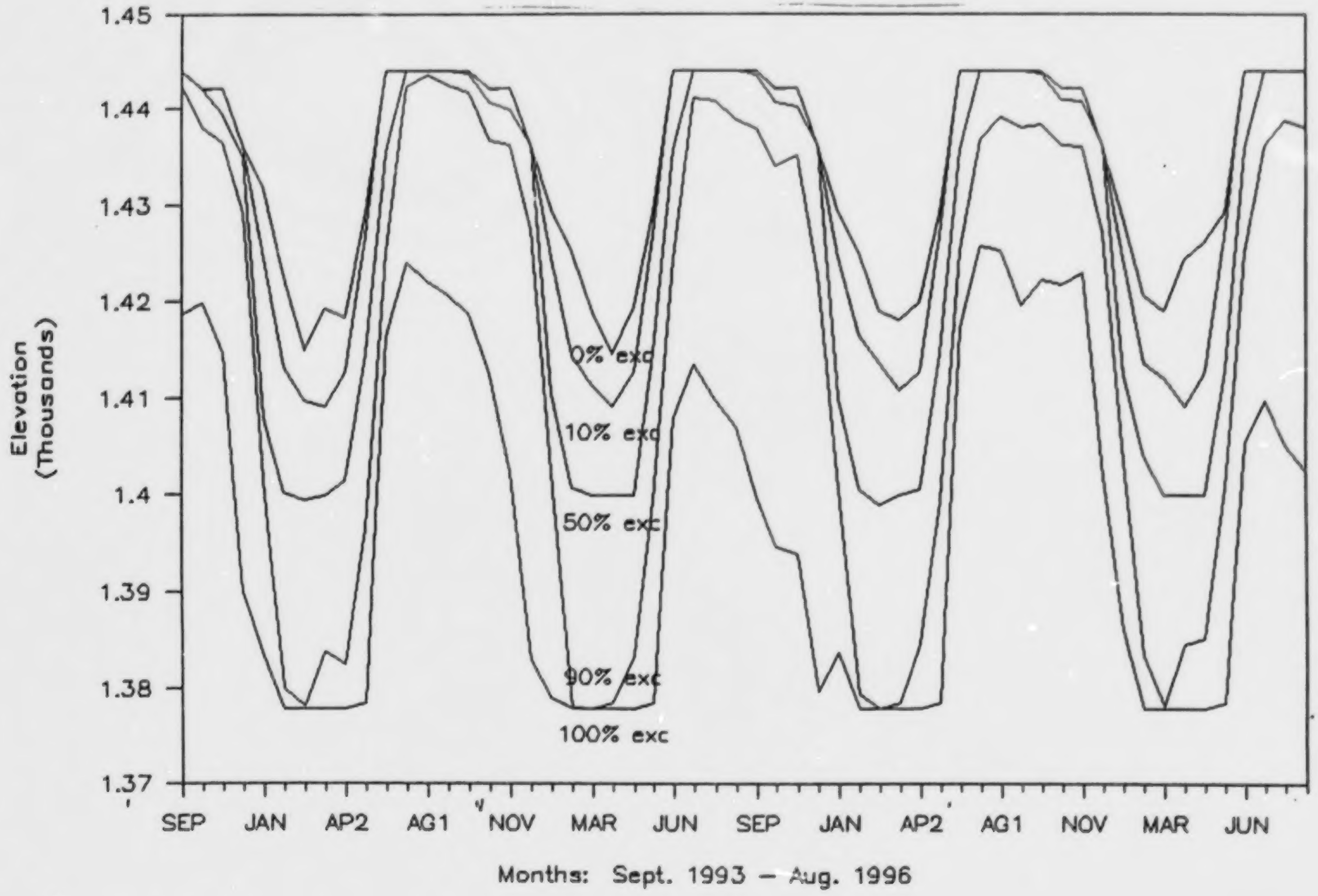


Figure A7.1.13 Elevations at Arrow Lakes Reservoir, Base Case (Medium Load): September 1997 - August 2000

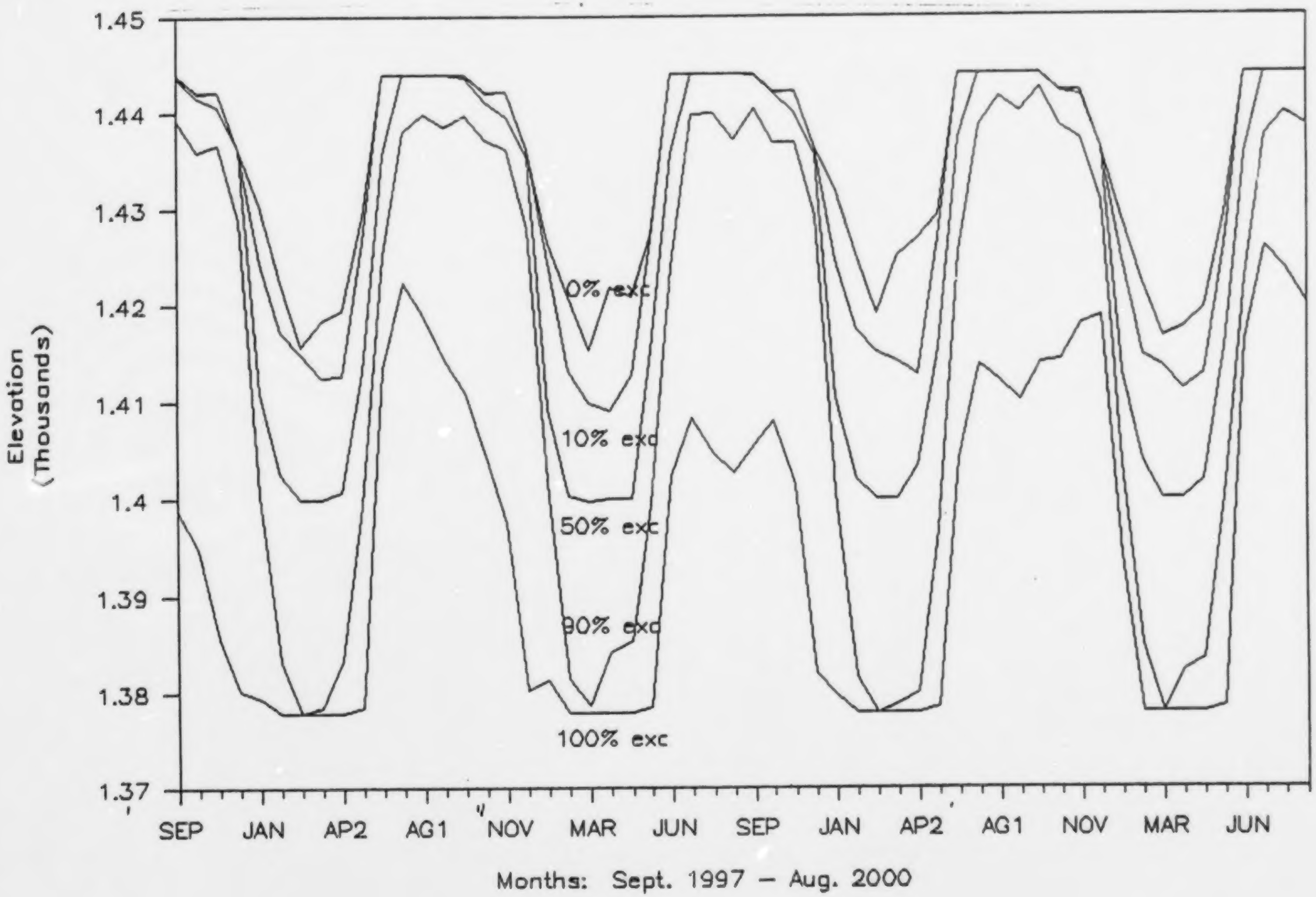


Figure A7.1.14 Elevations at Arrow Lakes Reservoir, Base Case (Medium Load): September 2001 - August 2004

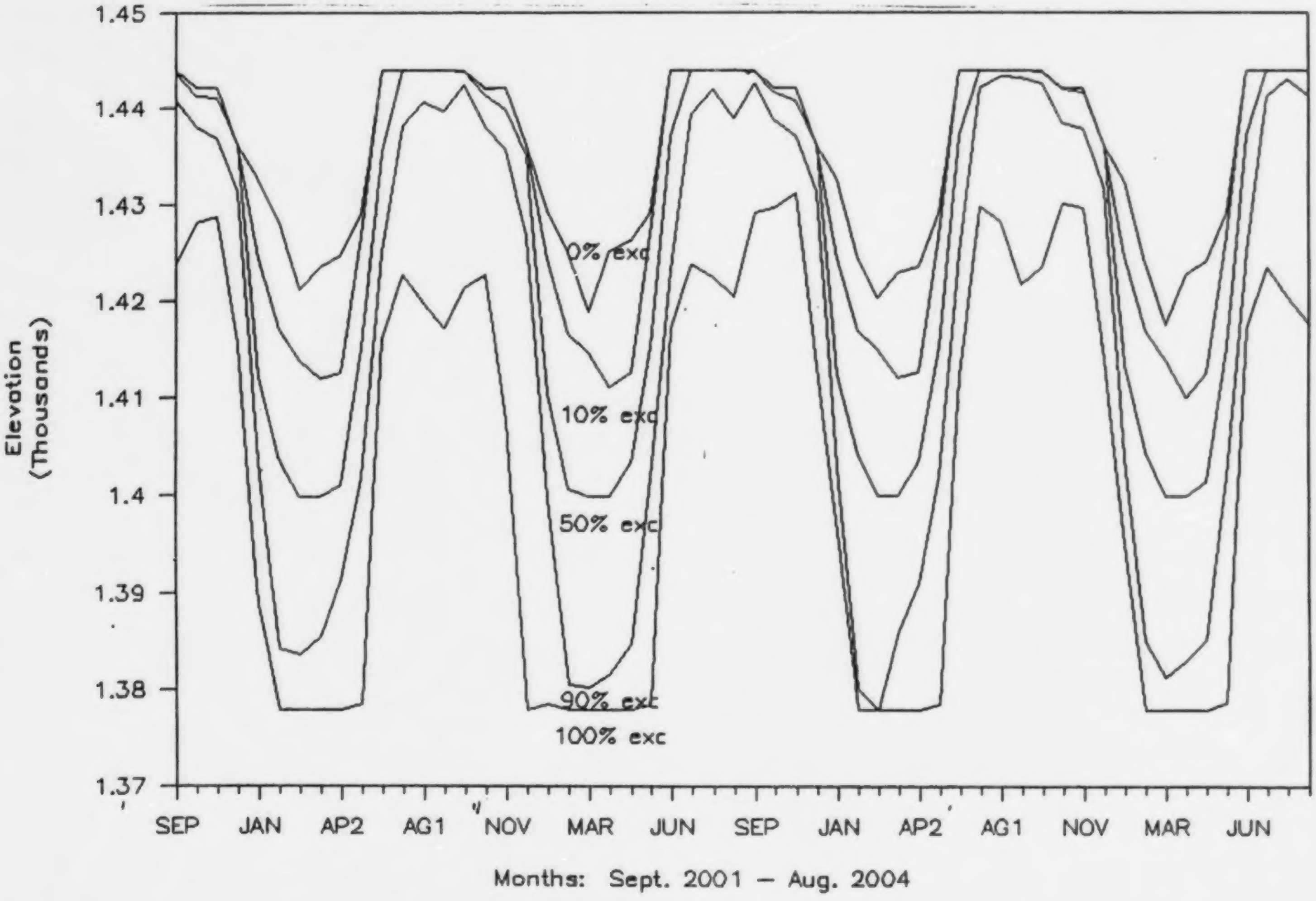


Figure A7.1.15 Elevations at Arrow Lakes Reservoir, Base Case (Medium Load): September 2005 - August 2008

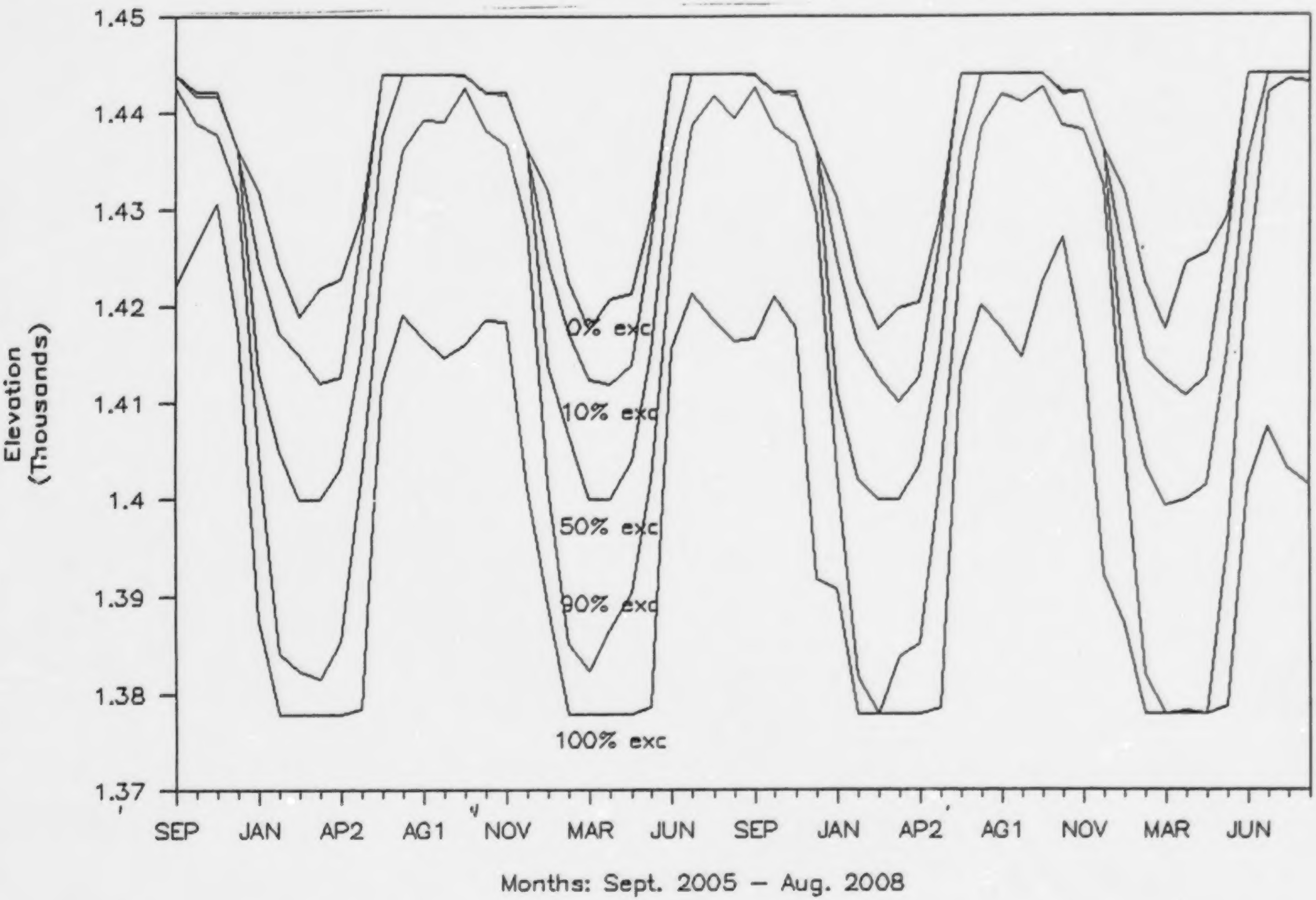
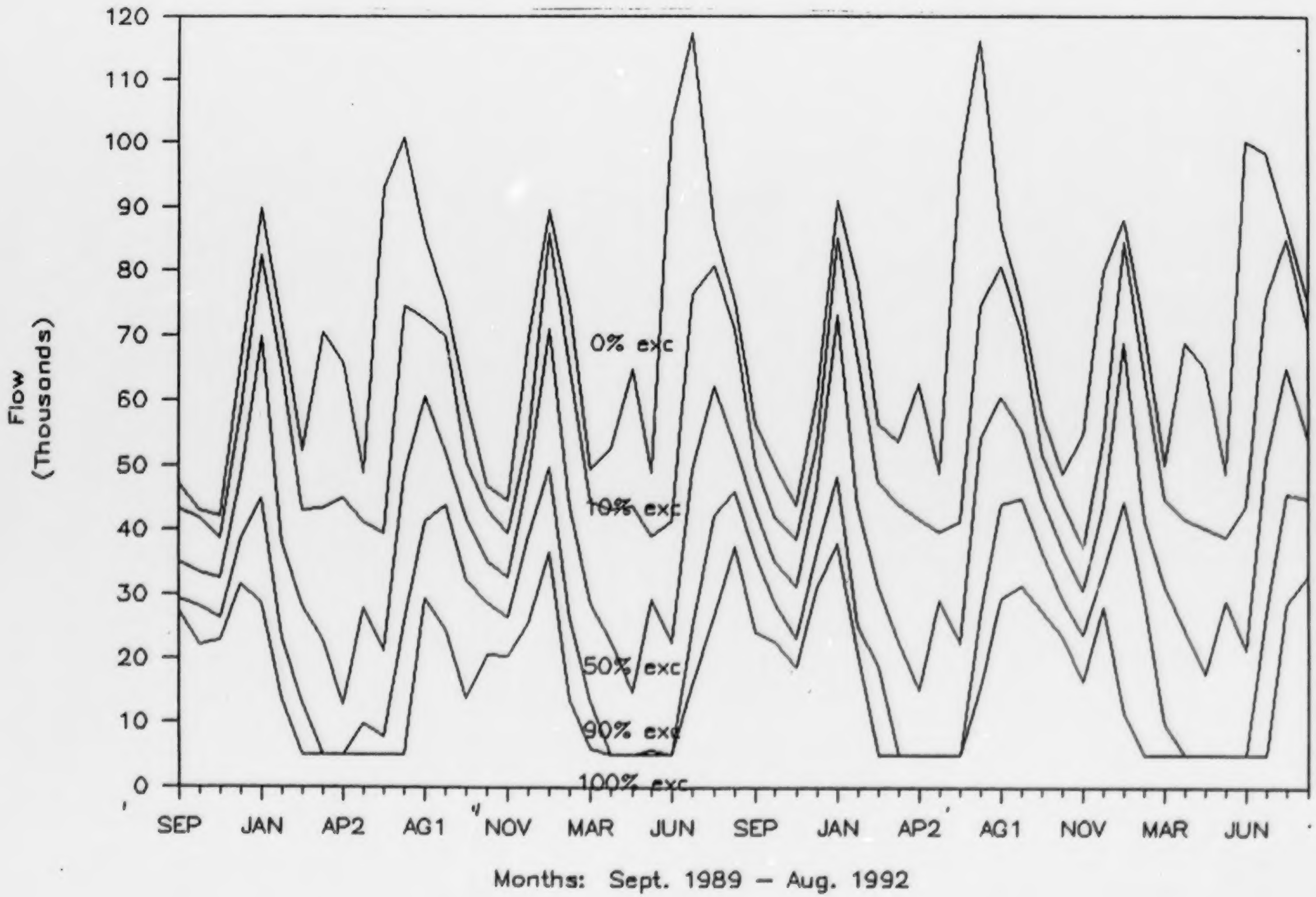


Figure A7.1.16 Flows at Arrow Lakes Reservoir, Base Case (Medium Load): September 1989 - August 1992



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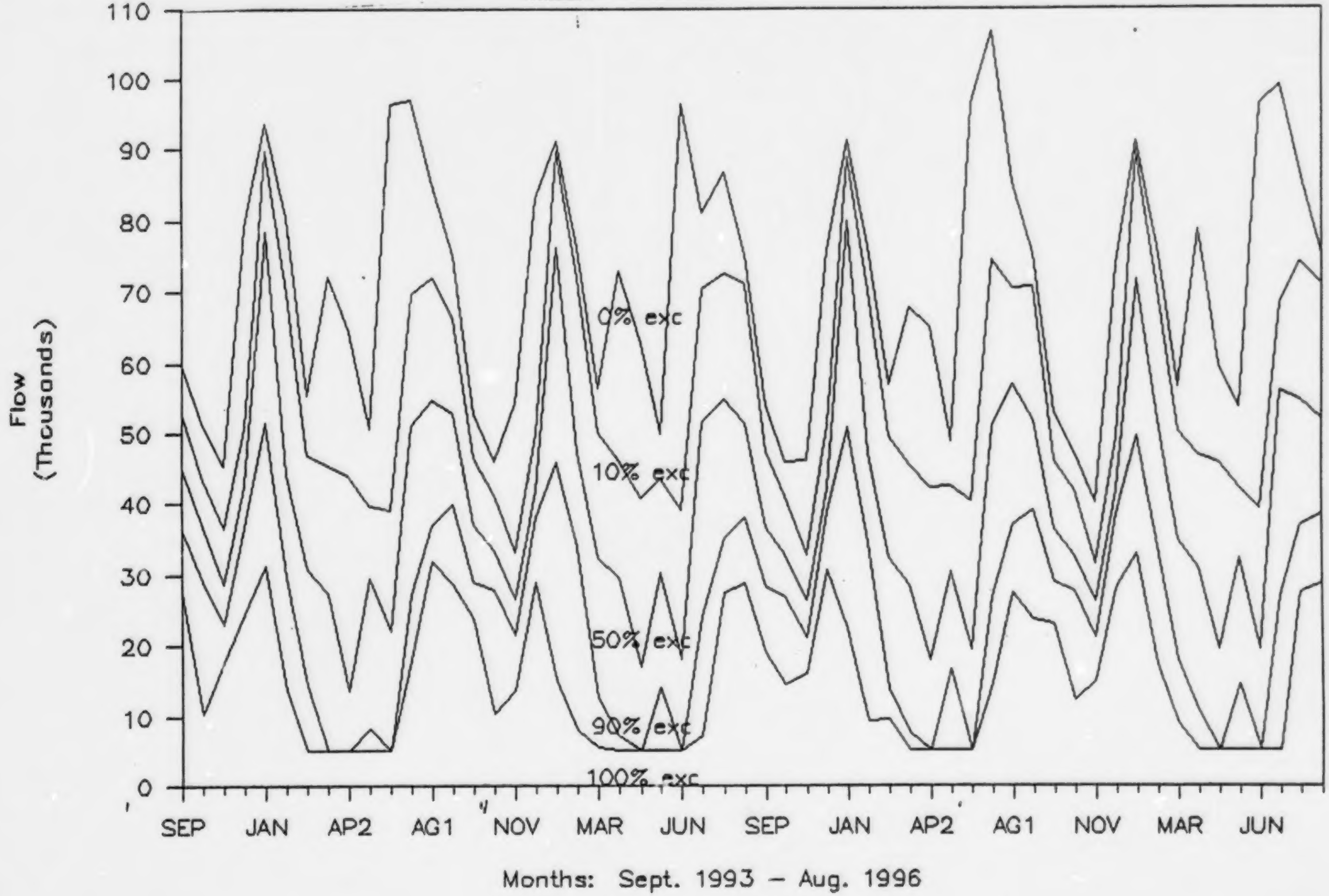


Figure A7.1.18 Flows at Arrow Lakes Reservoir, Base Case (Medium Load): September 1997 - August 2000

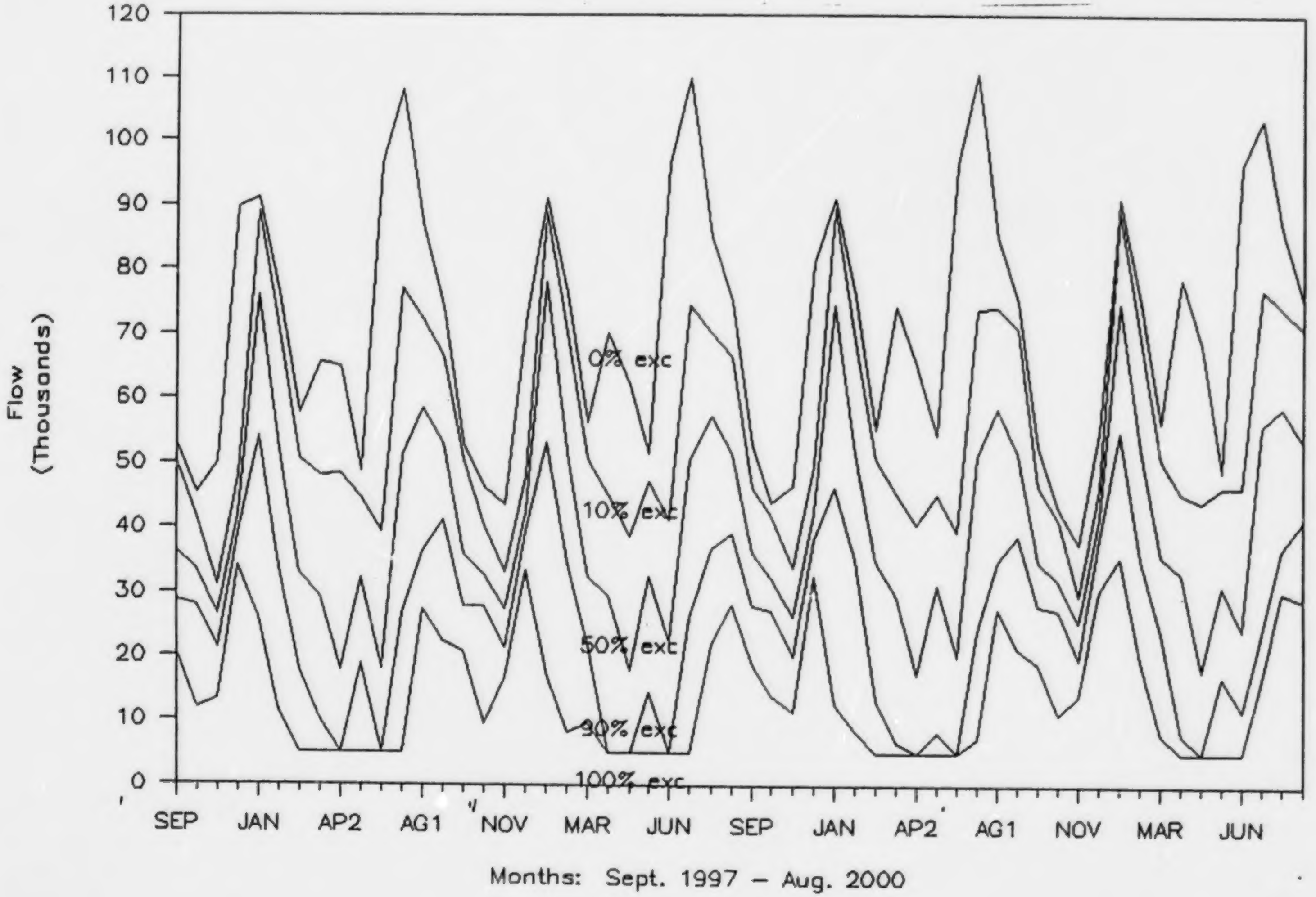


Figure A7.1.19 Flows at Arrow Lakes Reservoir, Base Case (Medium Load): September 2001 - August 2004

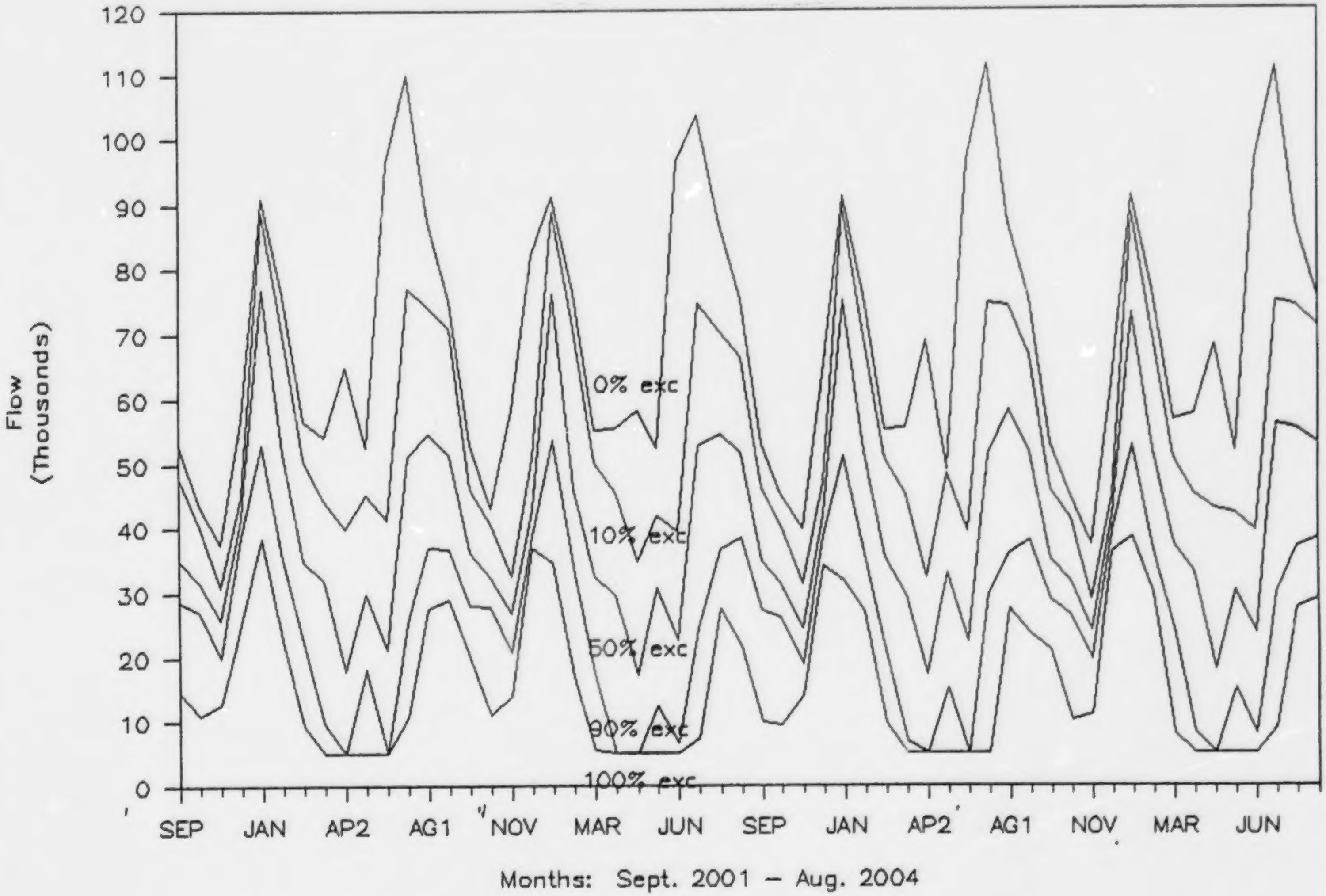
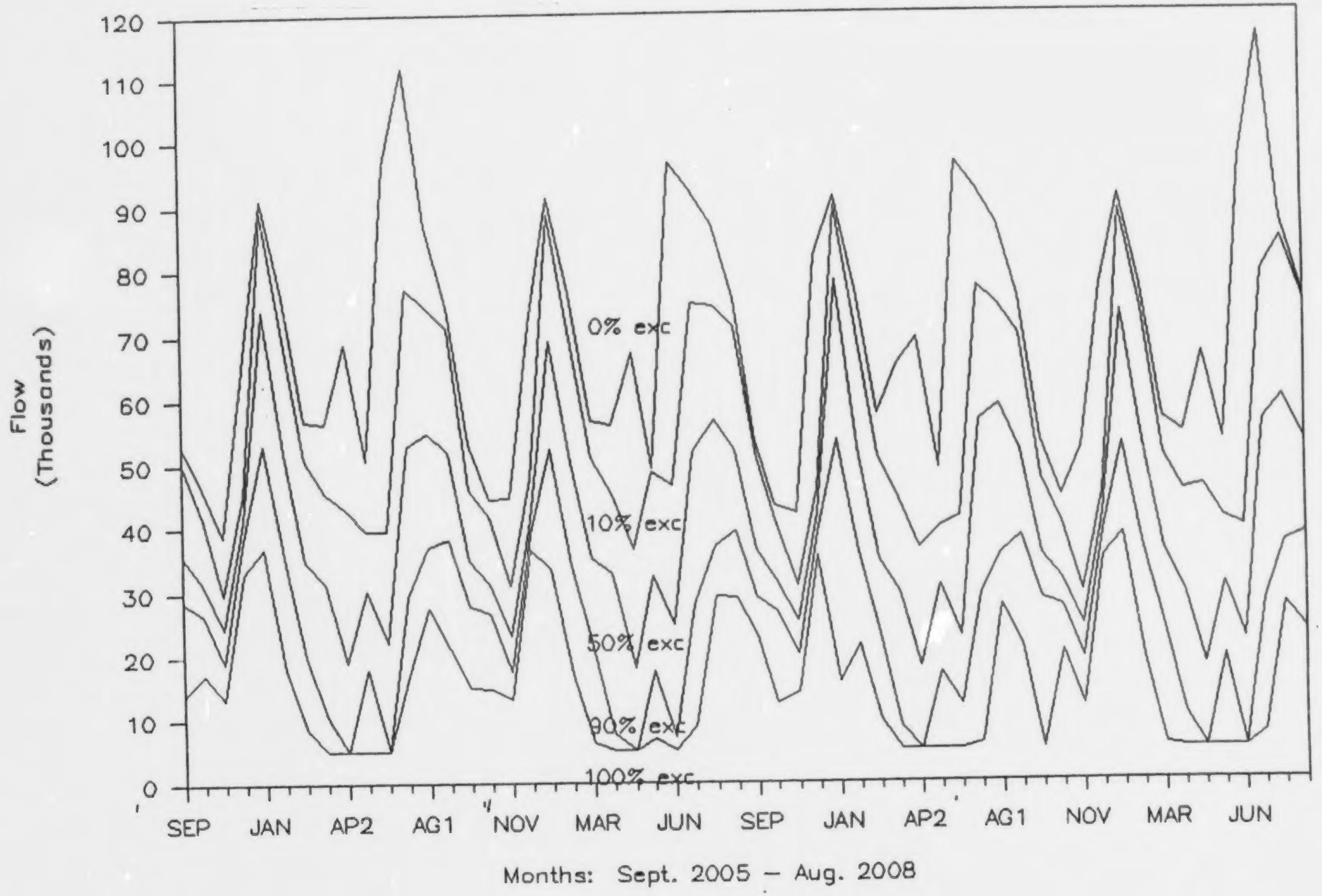


Figure A7.1.20 Flows at Arrow Lakes Reservoir, Base Case (Medium Load): September 2005 - August 2008



APPENDIX 7.2

Regime 1 (Medium Load)

Figure A7.2.1 Elevations at Mica Reservoir, Regime 1 (Medium Load): September 1989 - August 1992

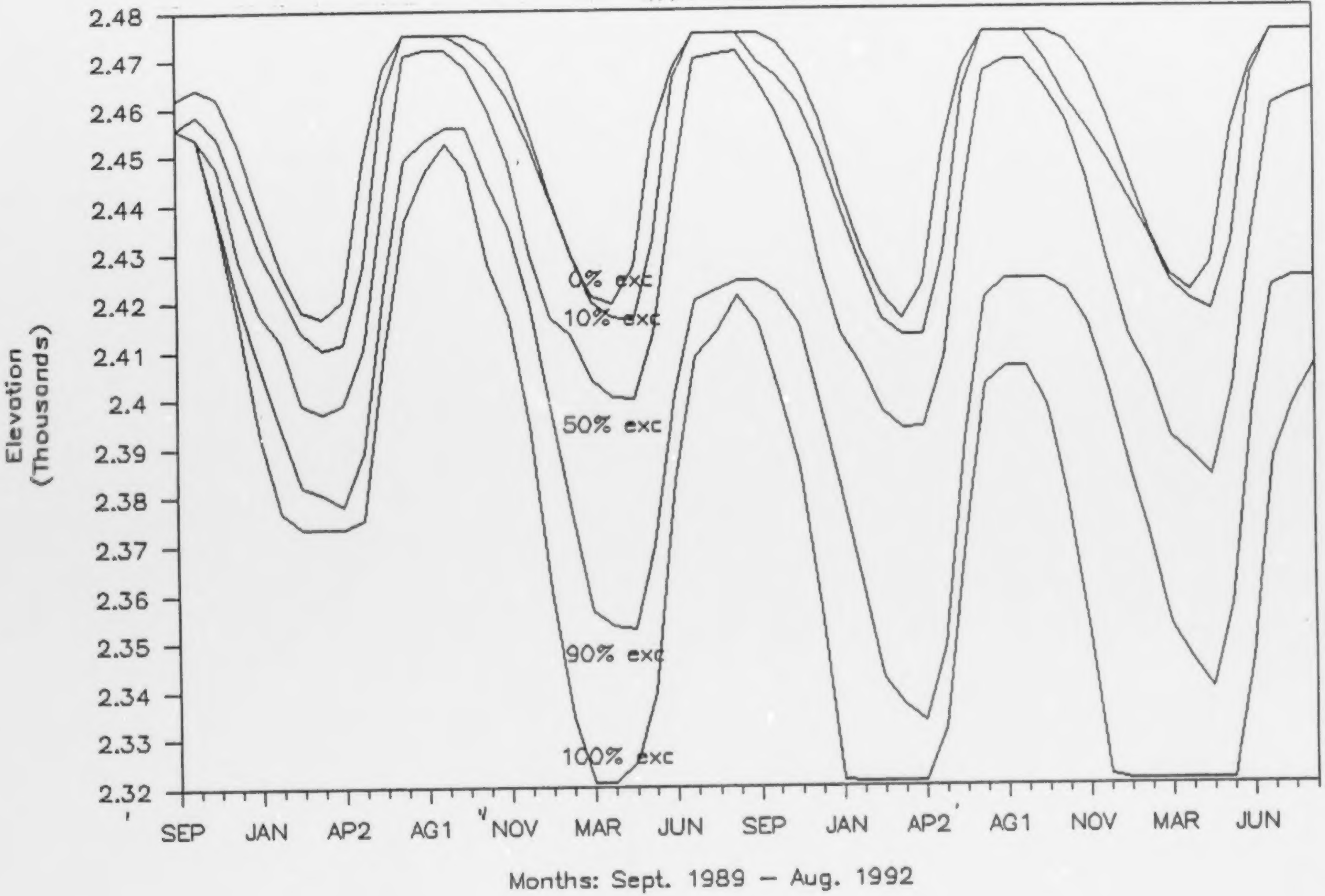


Figure A7.2.2 Elevations at Mica Reservoir, Regime 1 (Medium Load): September 1993 - August 1996

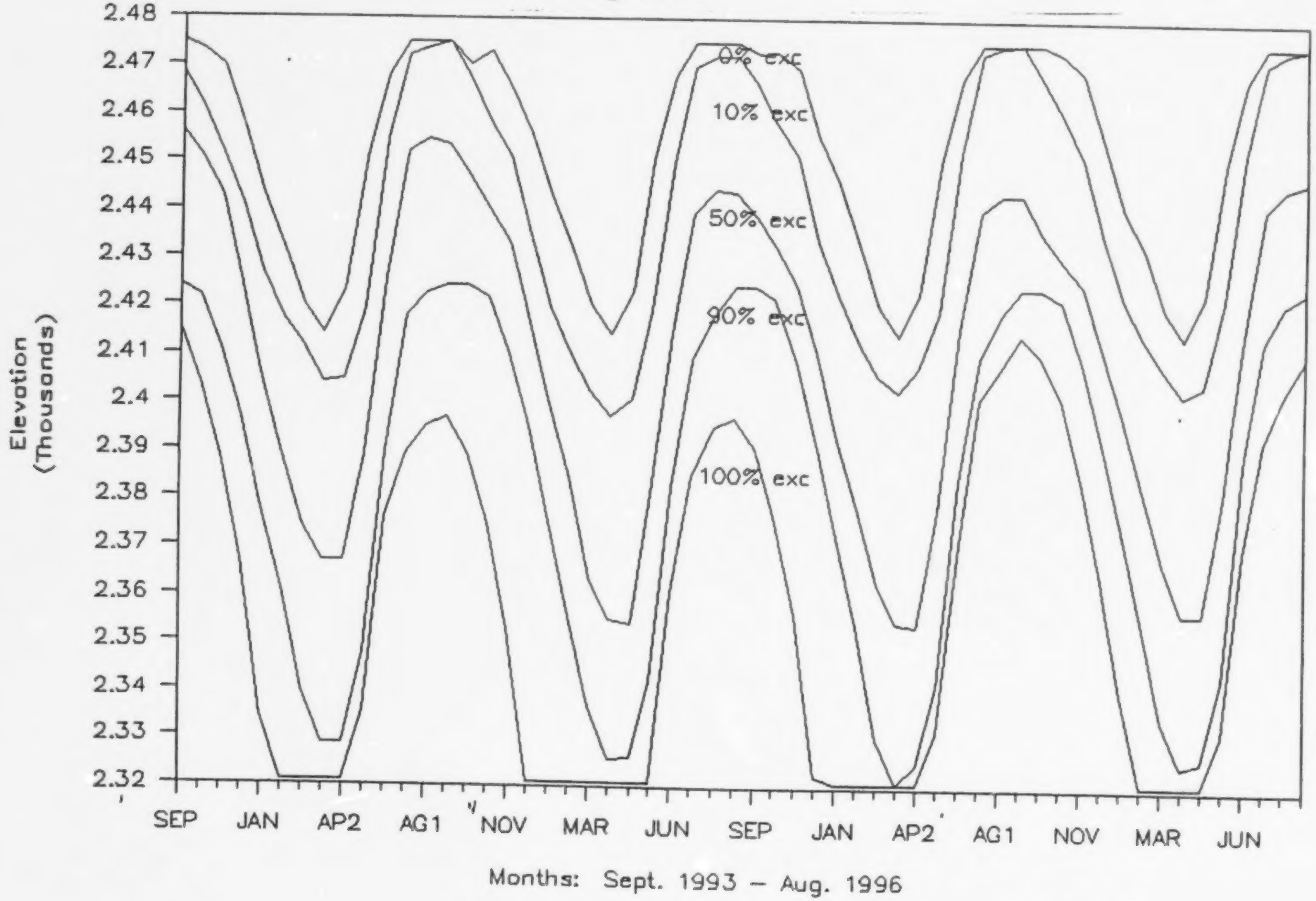


Figure A7.2.3 Elevations at Mica Reservoir, Regime 1 (Medium Load): September 1997 - August 2000

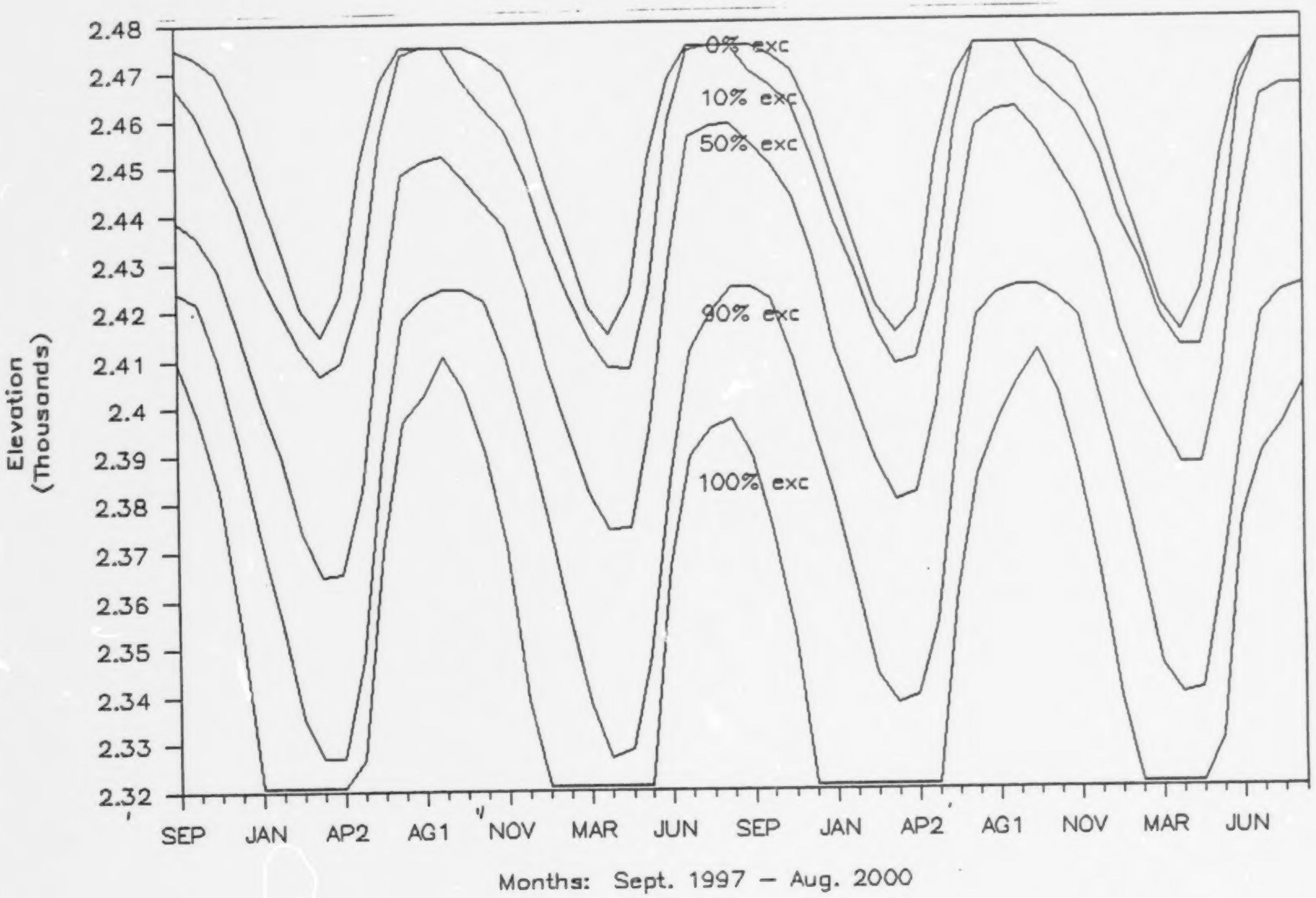


Figure A7.2.4 Elevations at Mica Reservoir, Regime 1 (Medium Load): September 2001 - August 2004

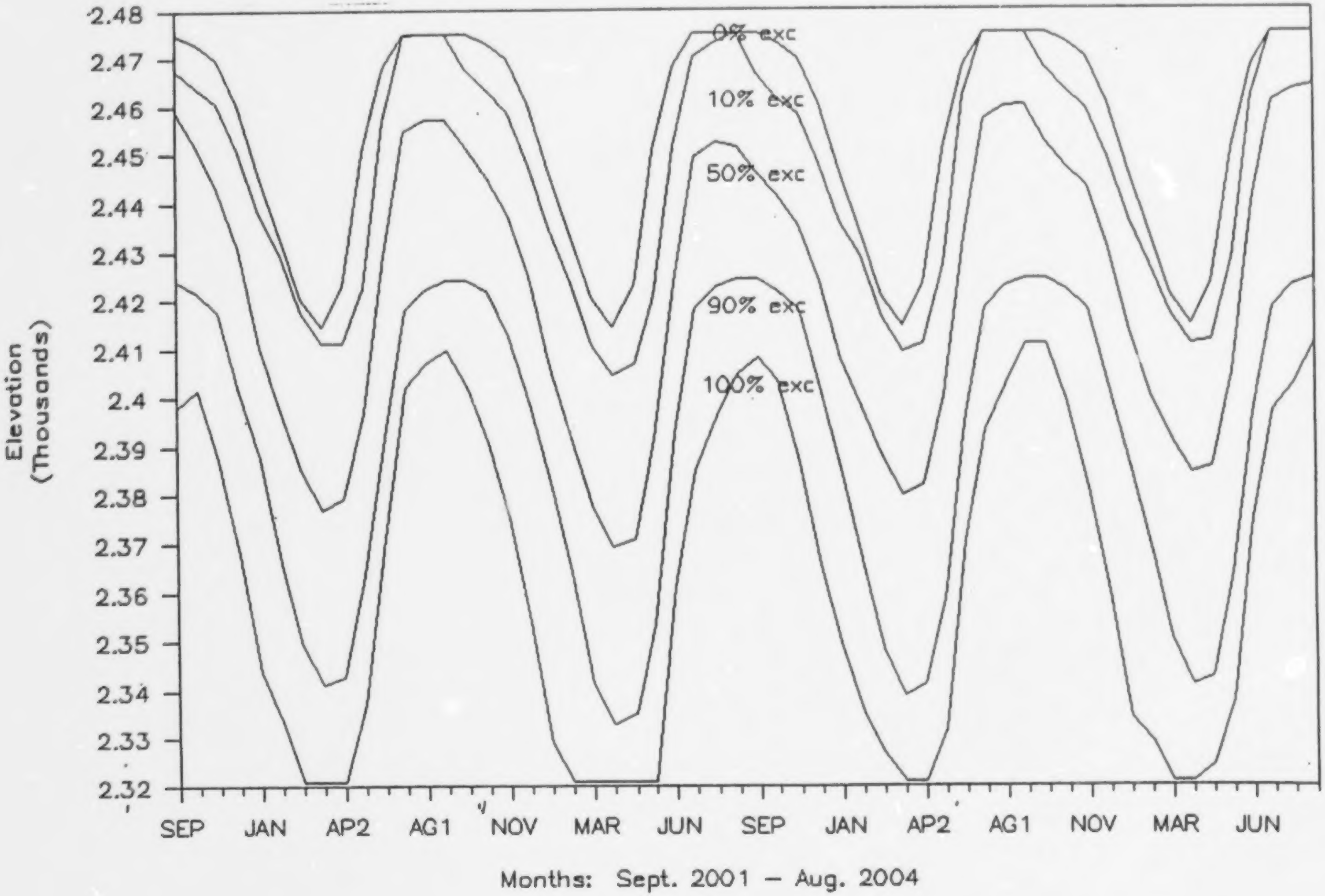


Figure A7.2.5 Elevations at Mica Reservoir, Regime 1 (Medium Load): September 2005 - August 2008

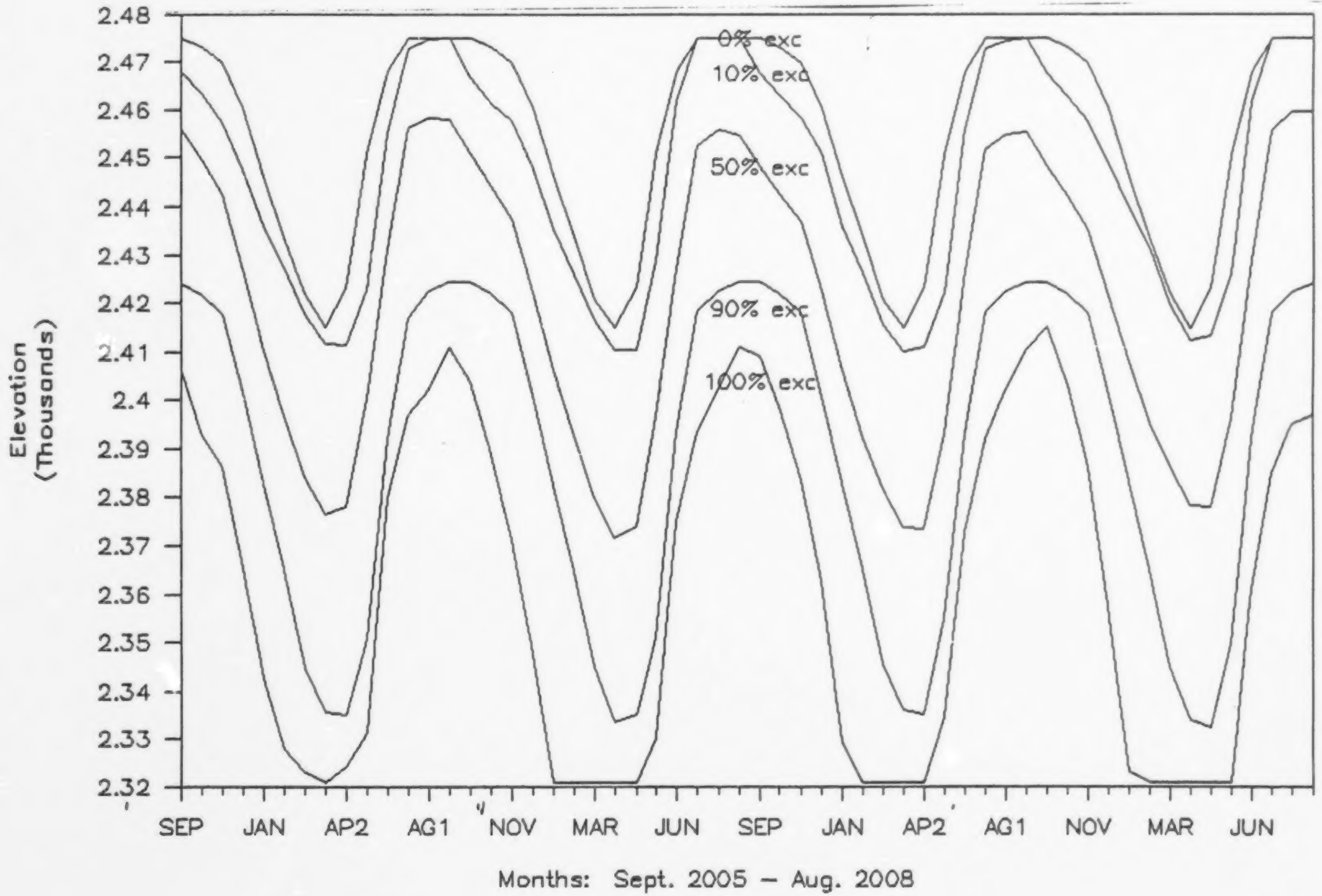


Figure A7.2.6 Flows at Mica Reservoir, Regime 1 (Medium Load): September 1989 - August 1992

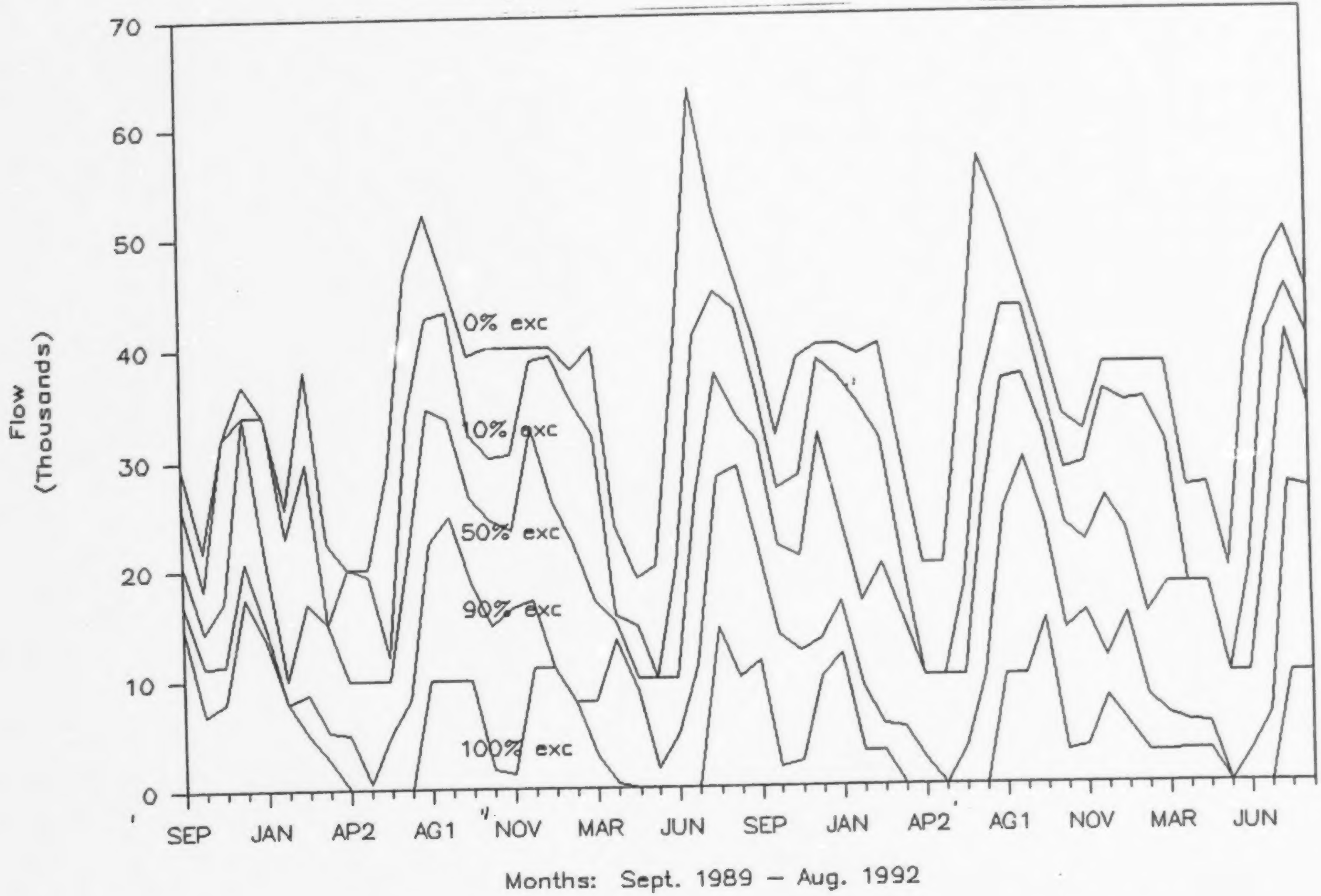


Figure A7.2.7 Flows at Mica Reservoir, Regime 1 (Medium Load): September 1993 - August 1996

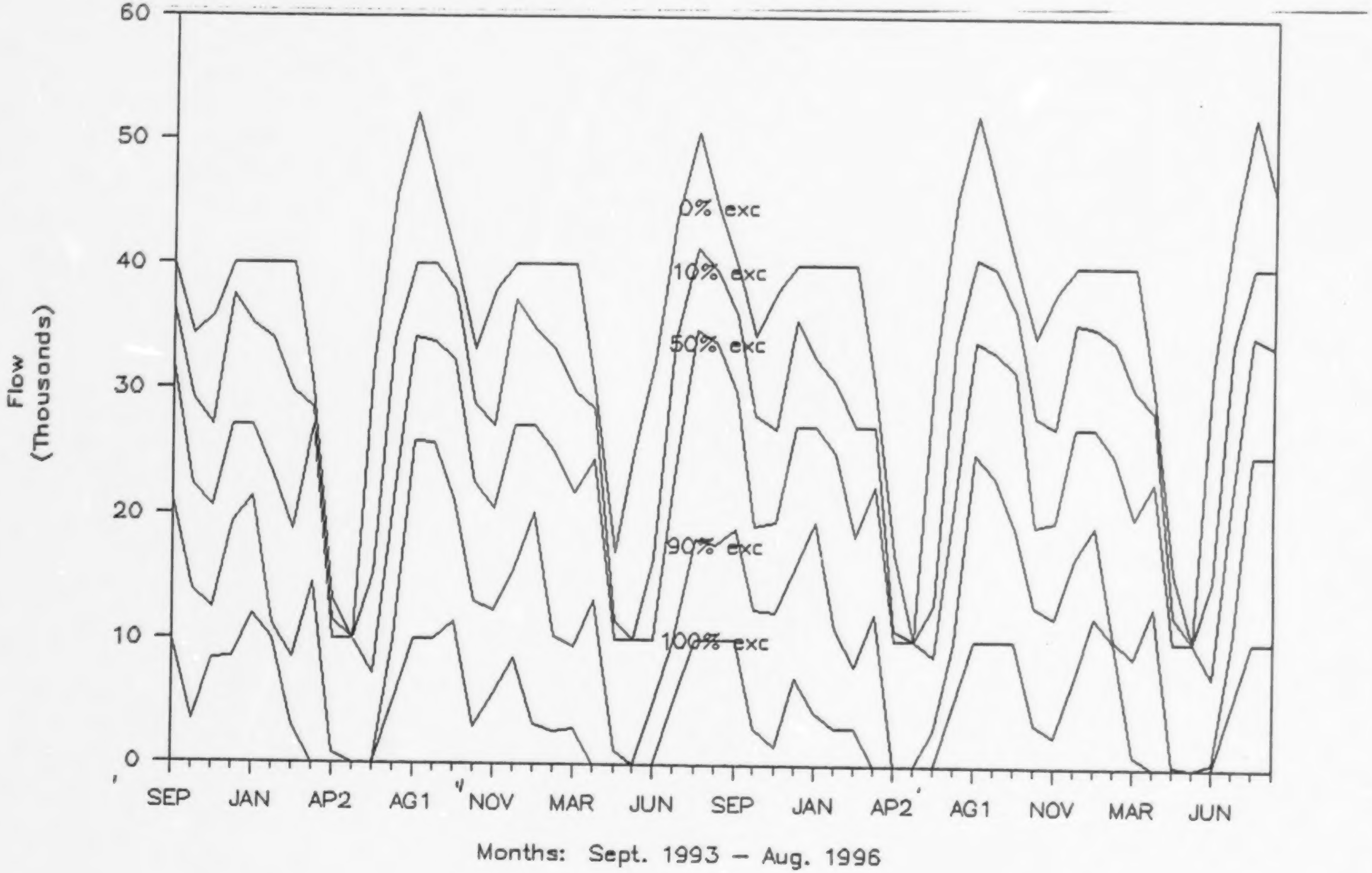


Figure A7.2.8 Flows at Mica Reservoir, Regime 1 (Medium Load): September 1997 - August 2000

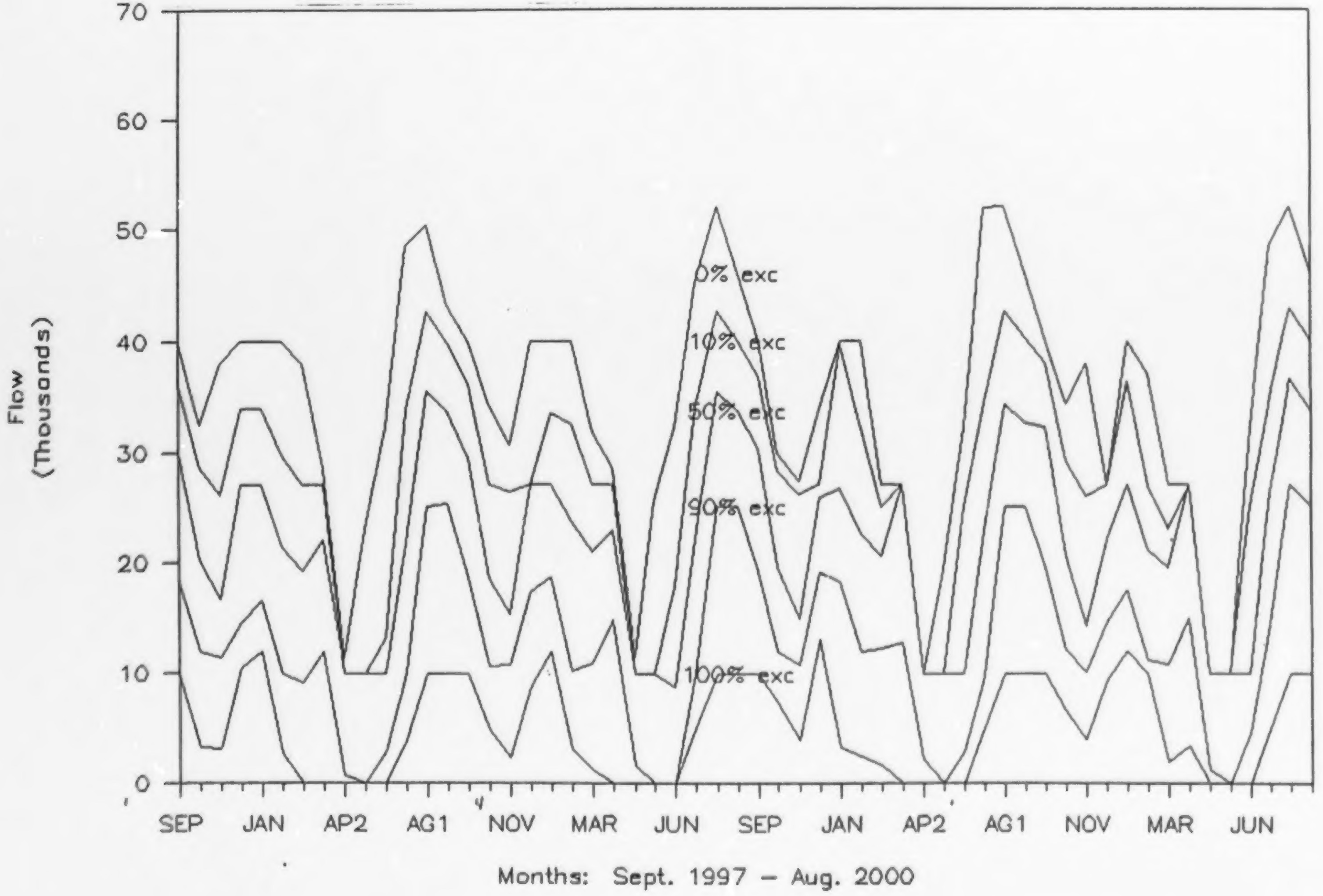


Figure A7.2.9 Flows at Mica Reservoir, Regime 1 (Medium Load): September 2001 - August 2004

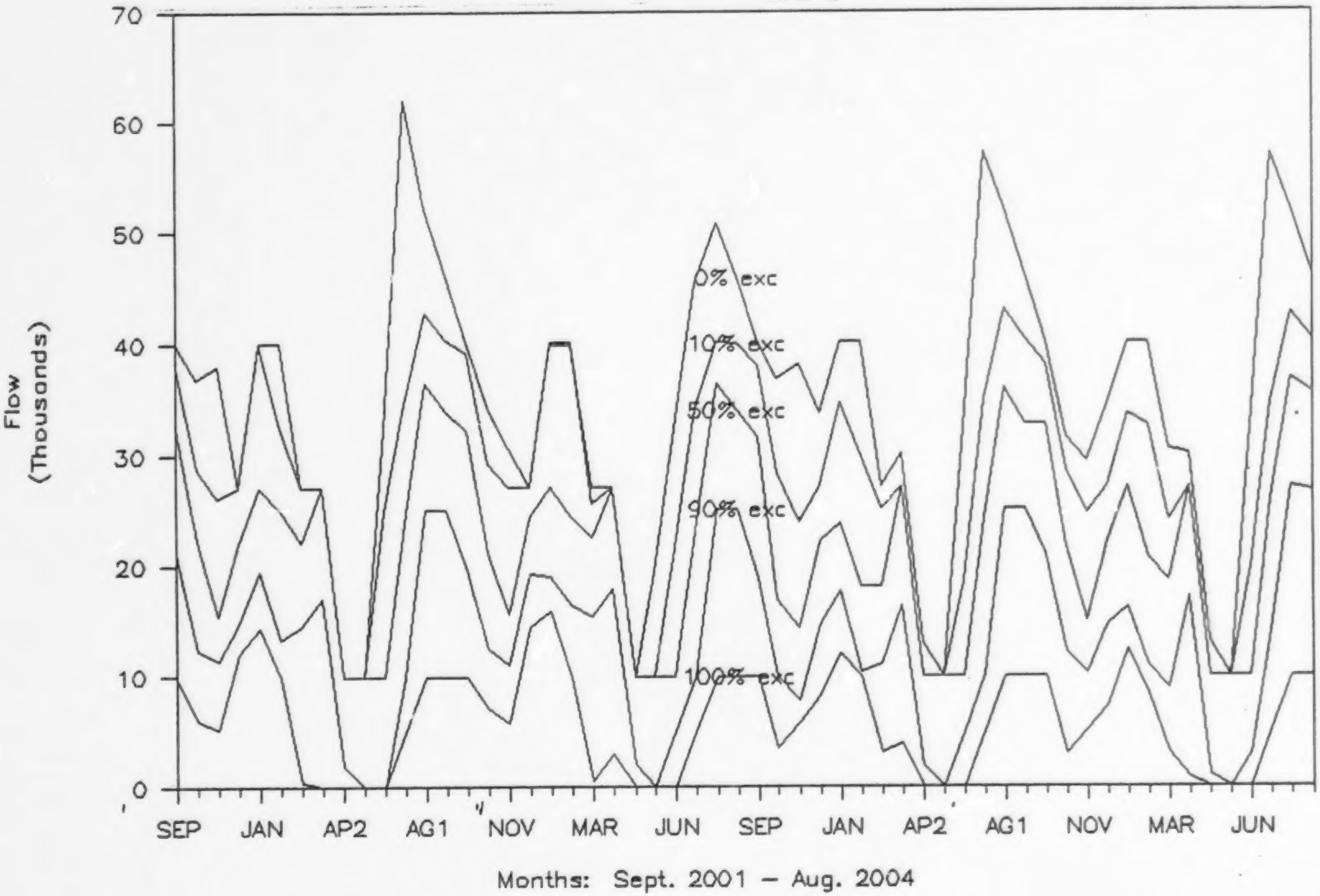


Figure A7.2.10 Flows at Mica Reservoir, Regime 1 (Medium Load): September 2005 - August 2008

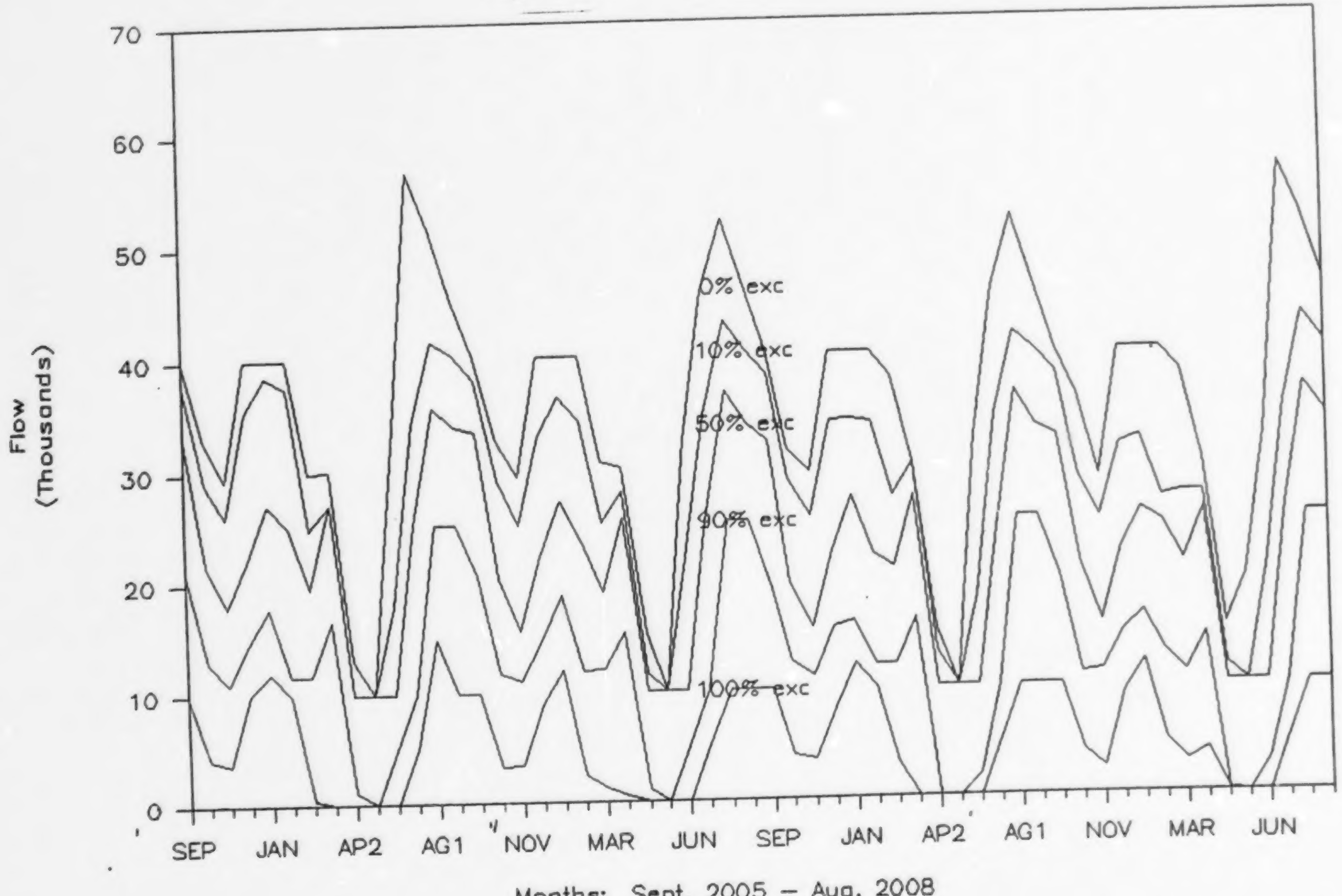


Figure A7.2.11 Elevations at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 1989 - August 1992

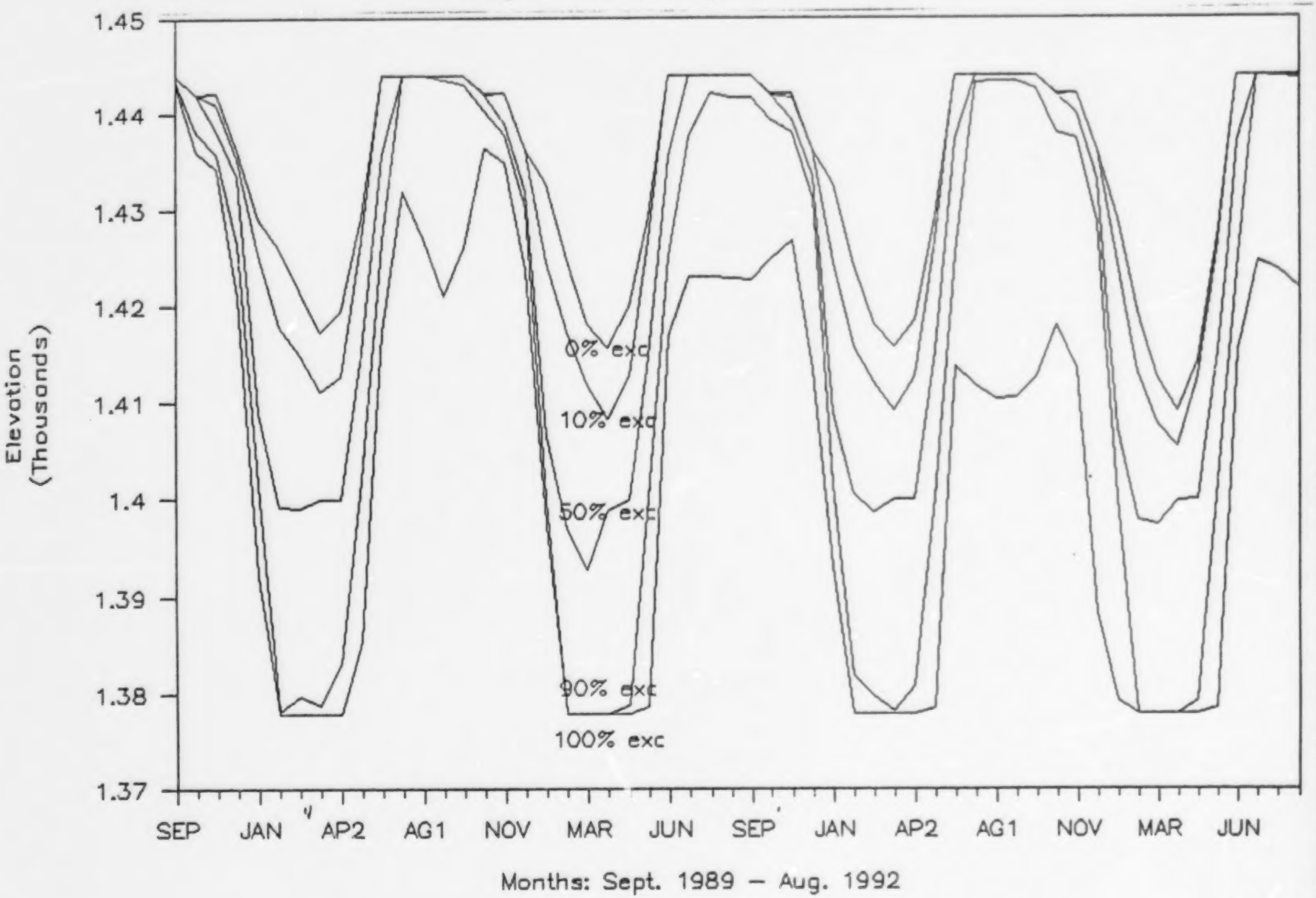


Figure A7.2.12 Elevations at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 1993 - August 1996

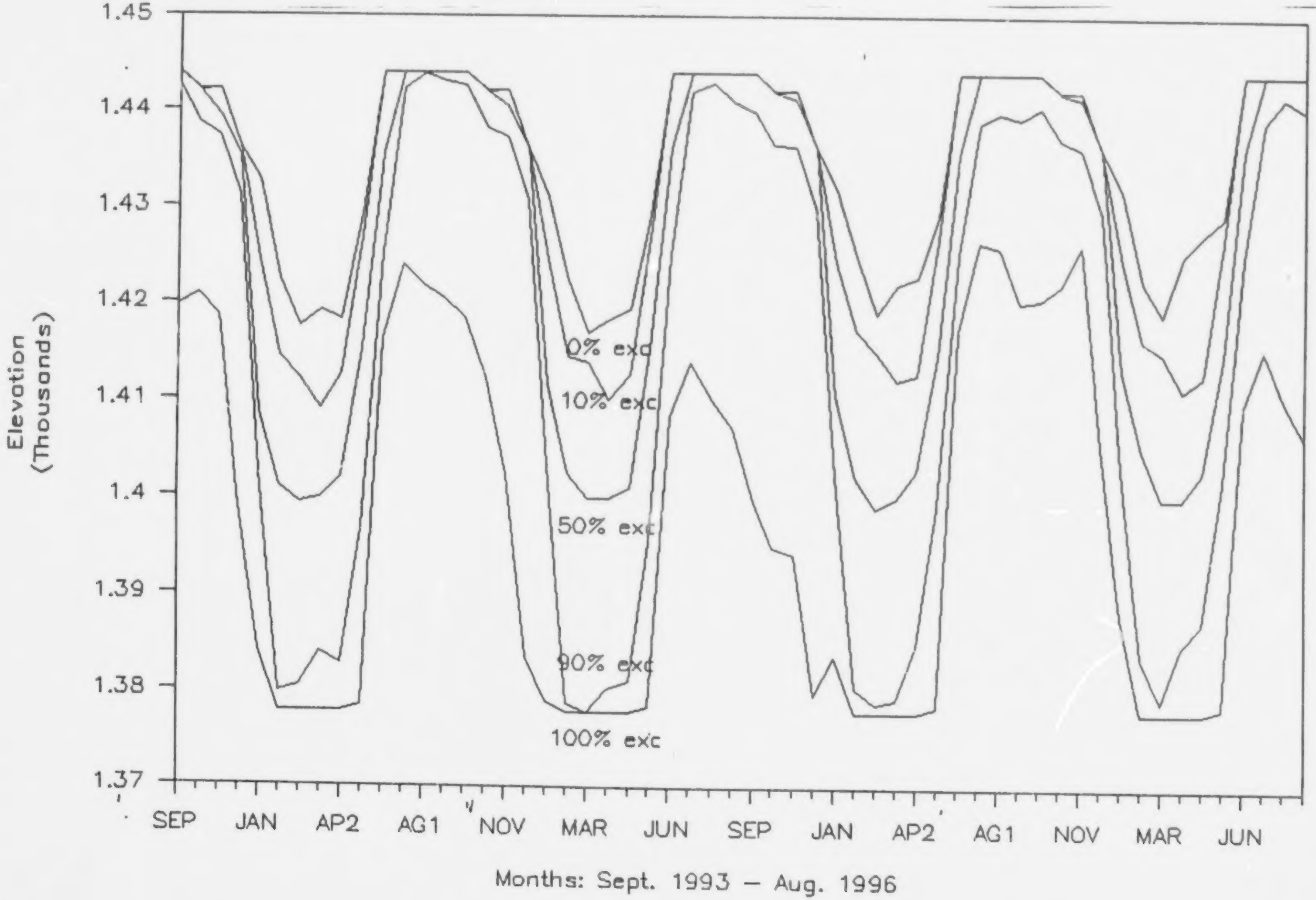


Figure A7.2.13 Elevations at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 1997 - August 2000

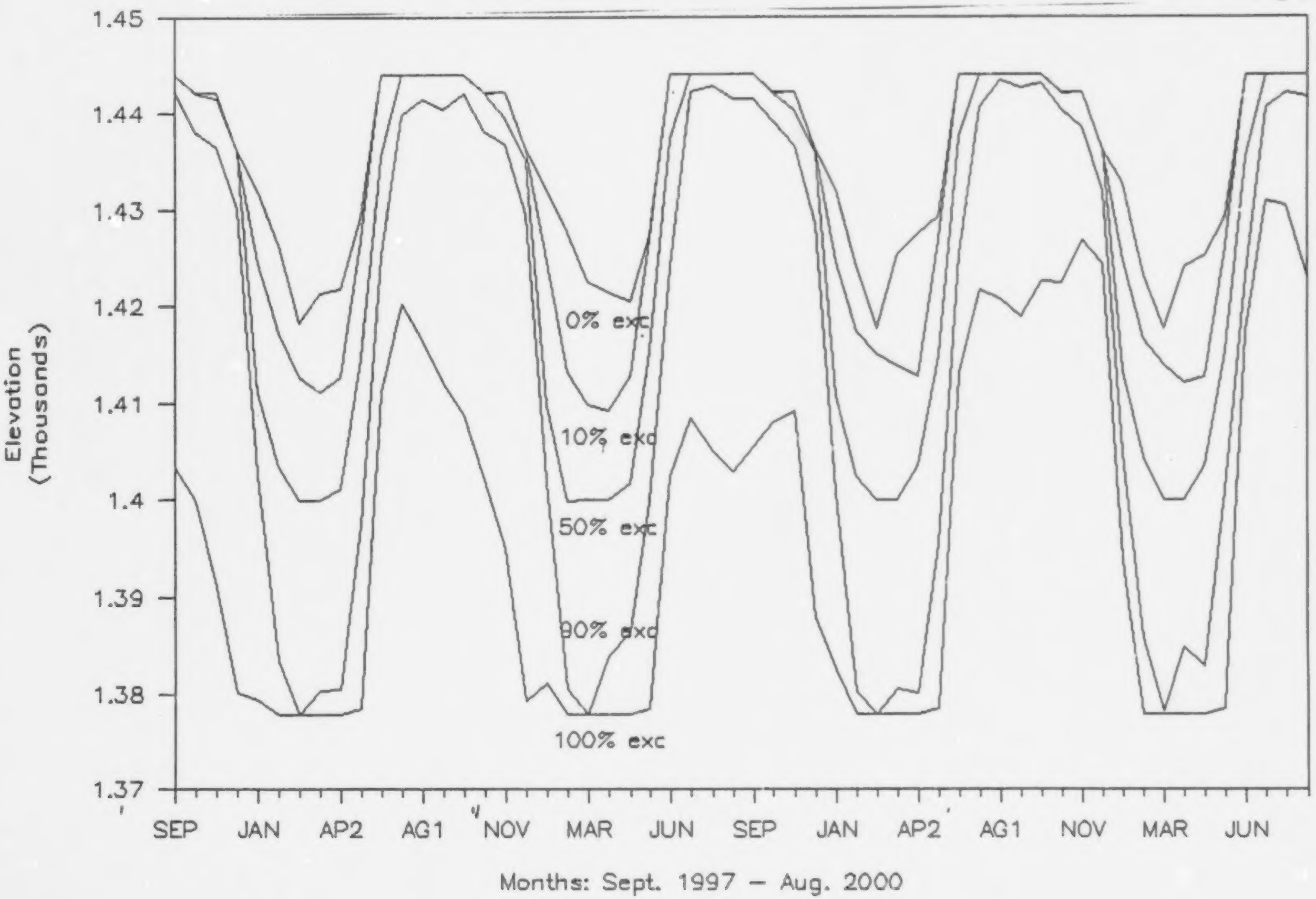


Figure A7.2.14 Elevations at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 2001 - August 2004

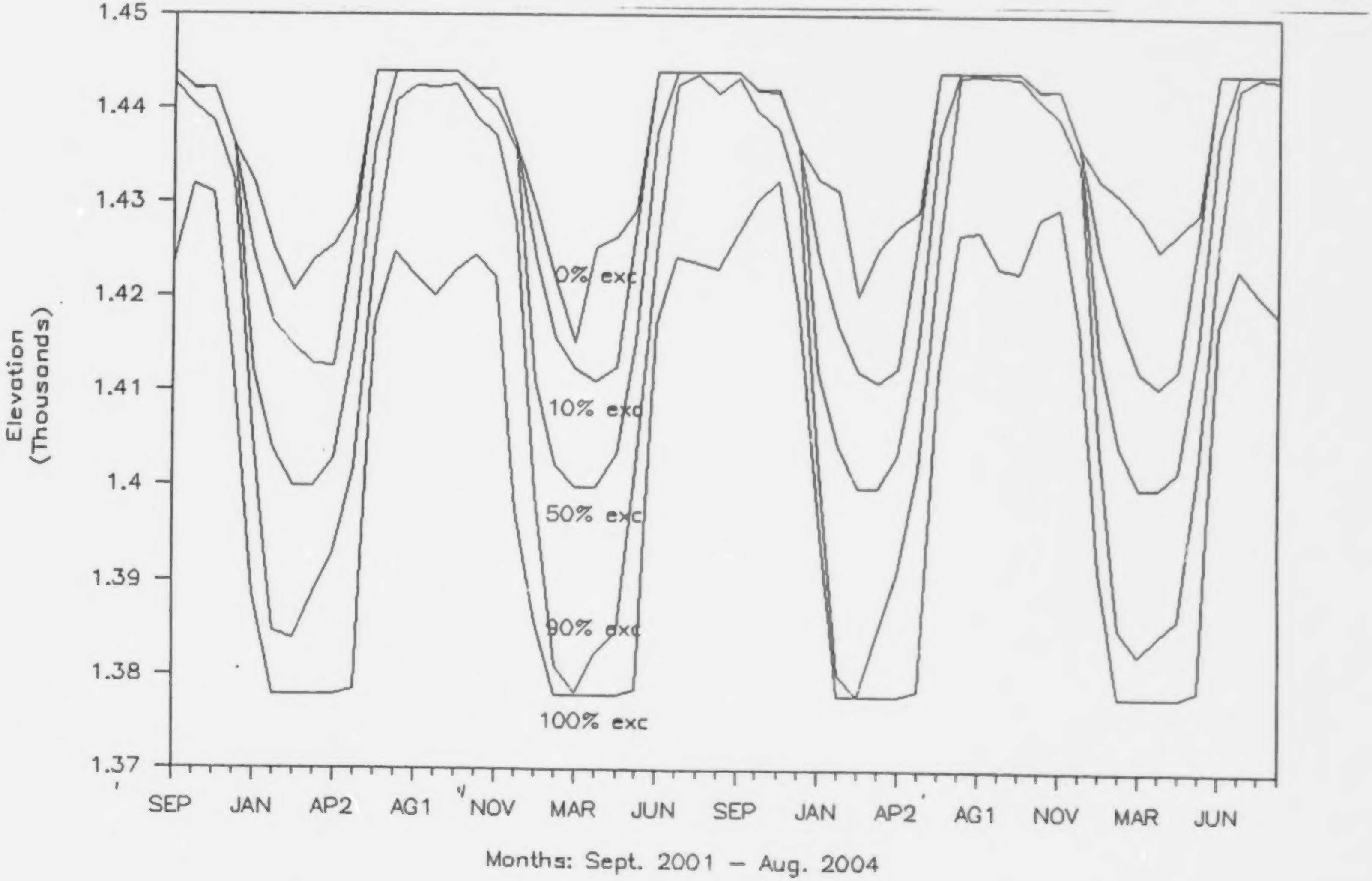


Figure A7.2.15 Elevations at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 2005 - August 2008

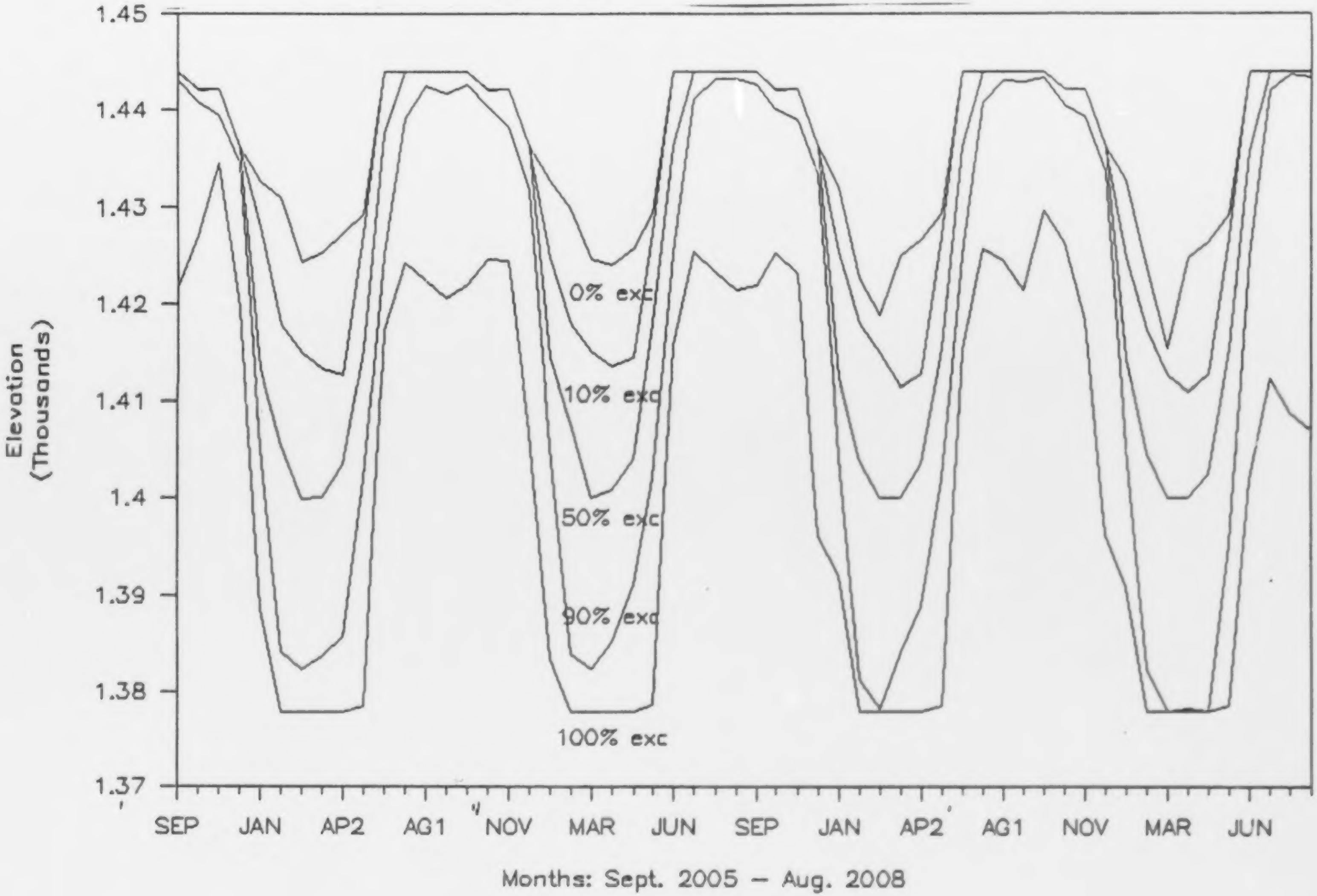


Figure A7.2.16 Flows at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 1989 - August 1992

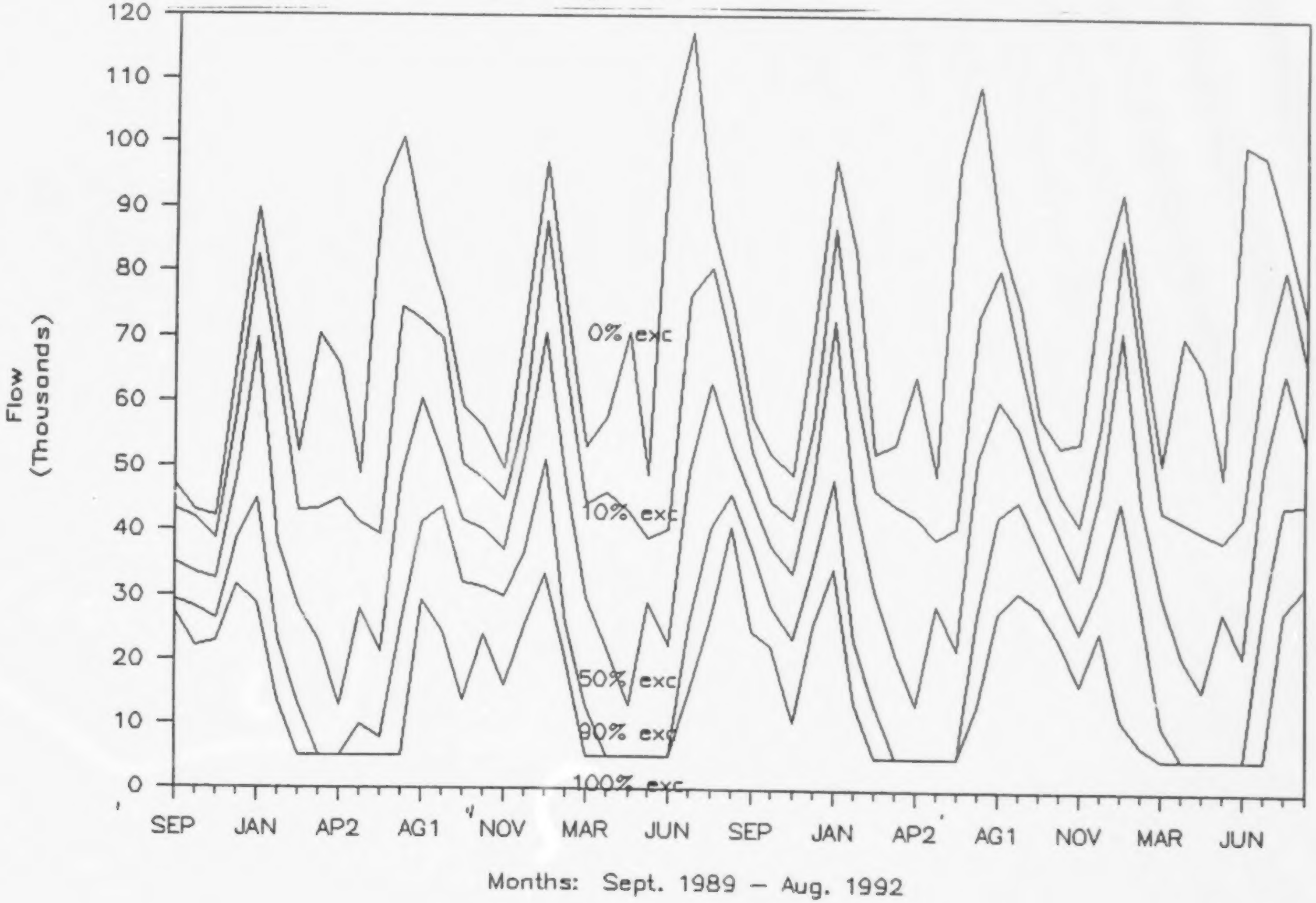


Figure A7.2.17 Flows at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 1993 - August 1996

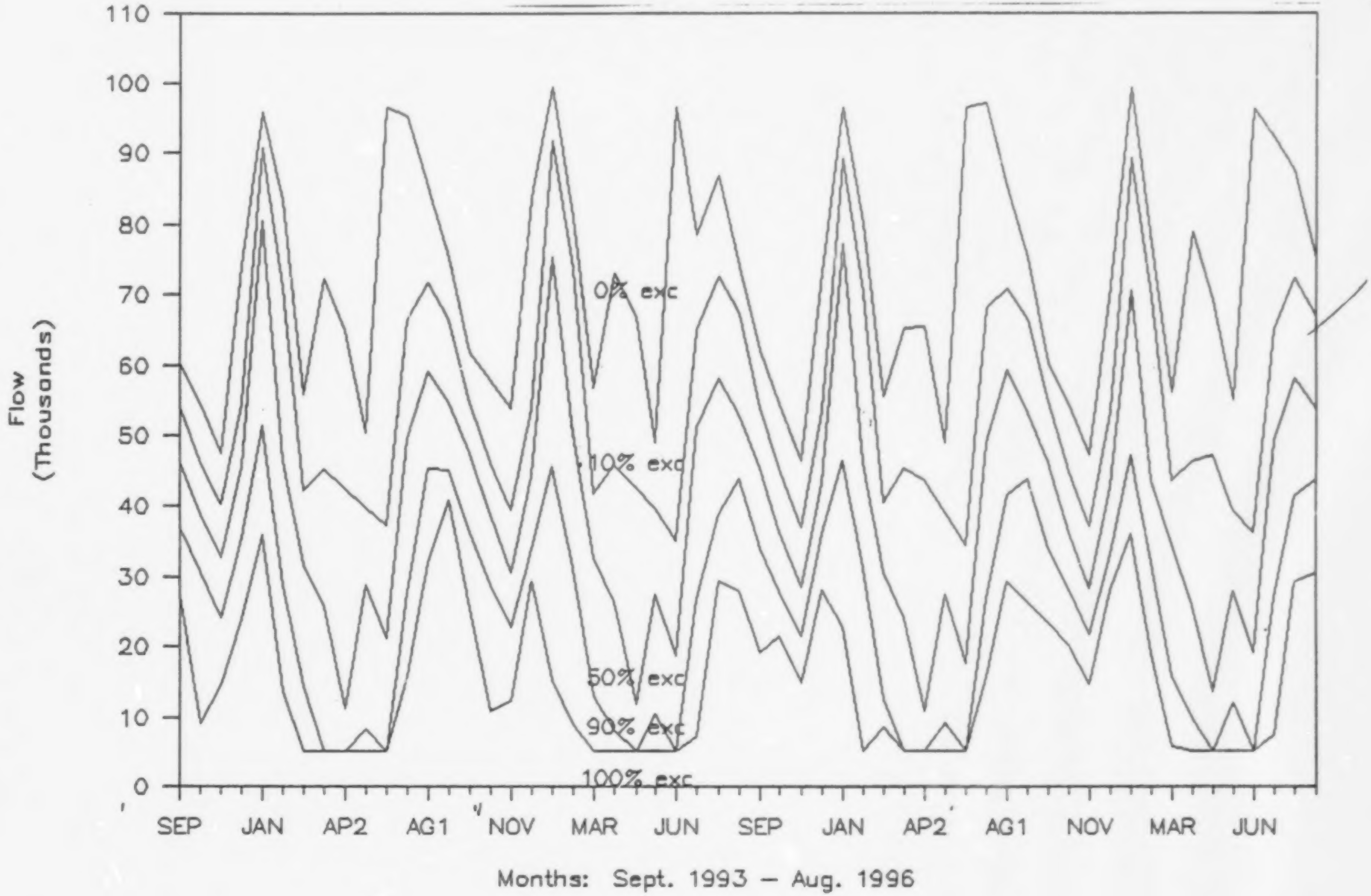


Figure A7.2.18 Flows at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 1997 - August 2000

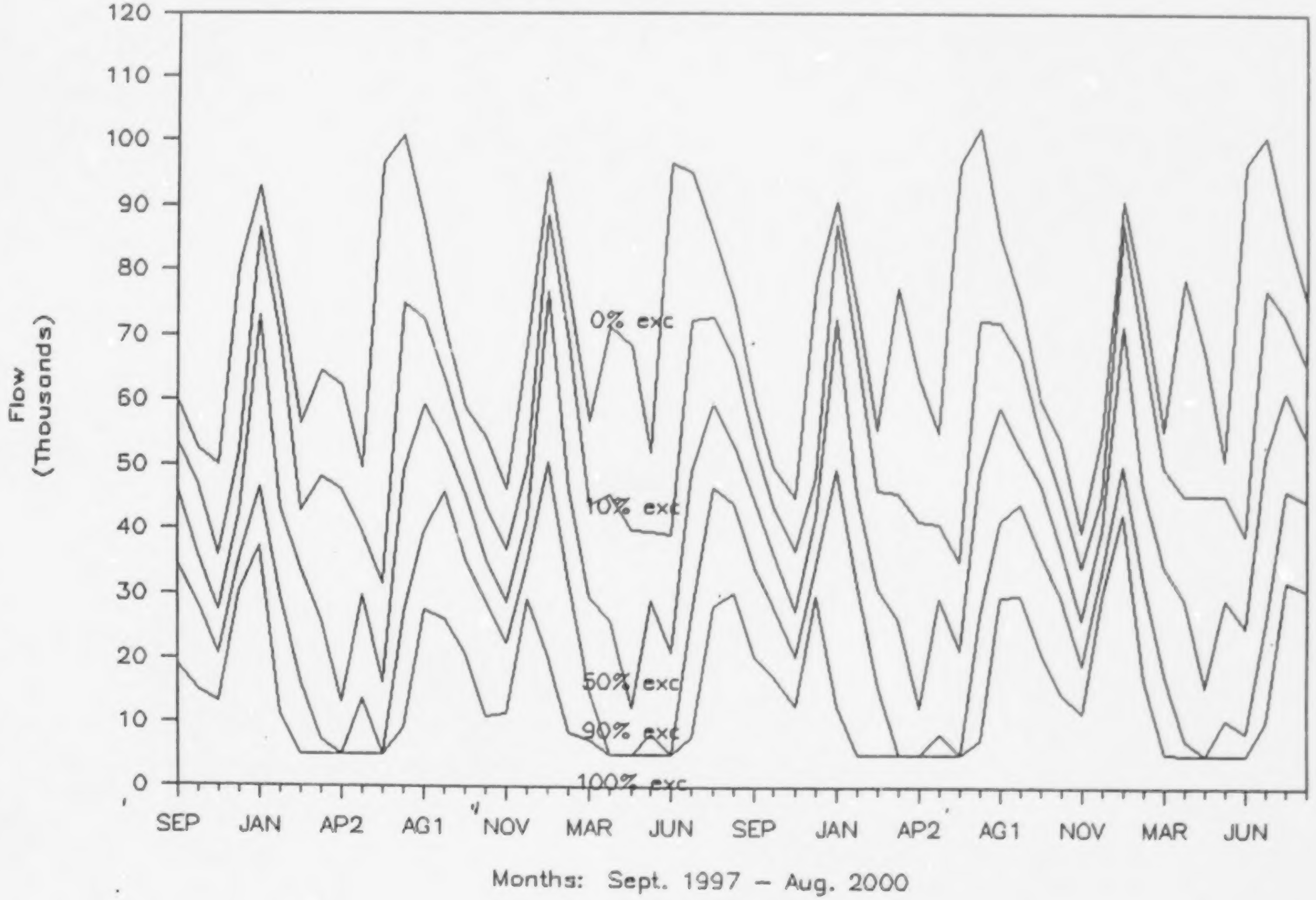


Figure A7.2.19 Flows at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 2001 - August 2004

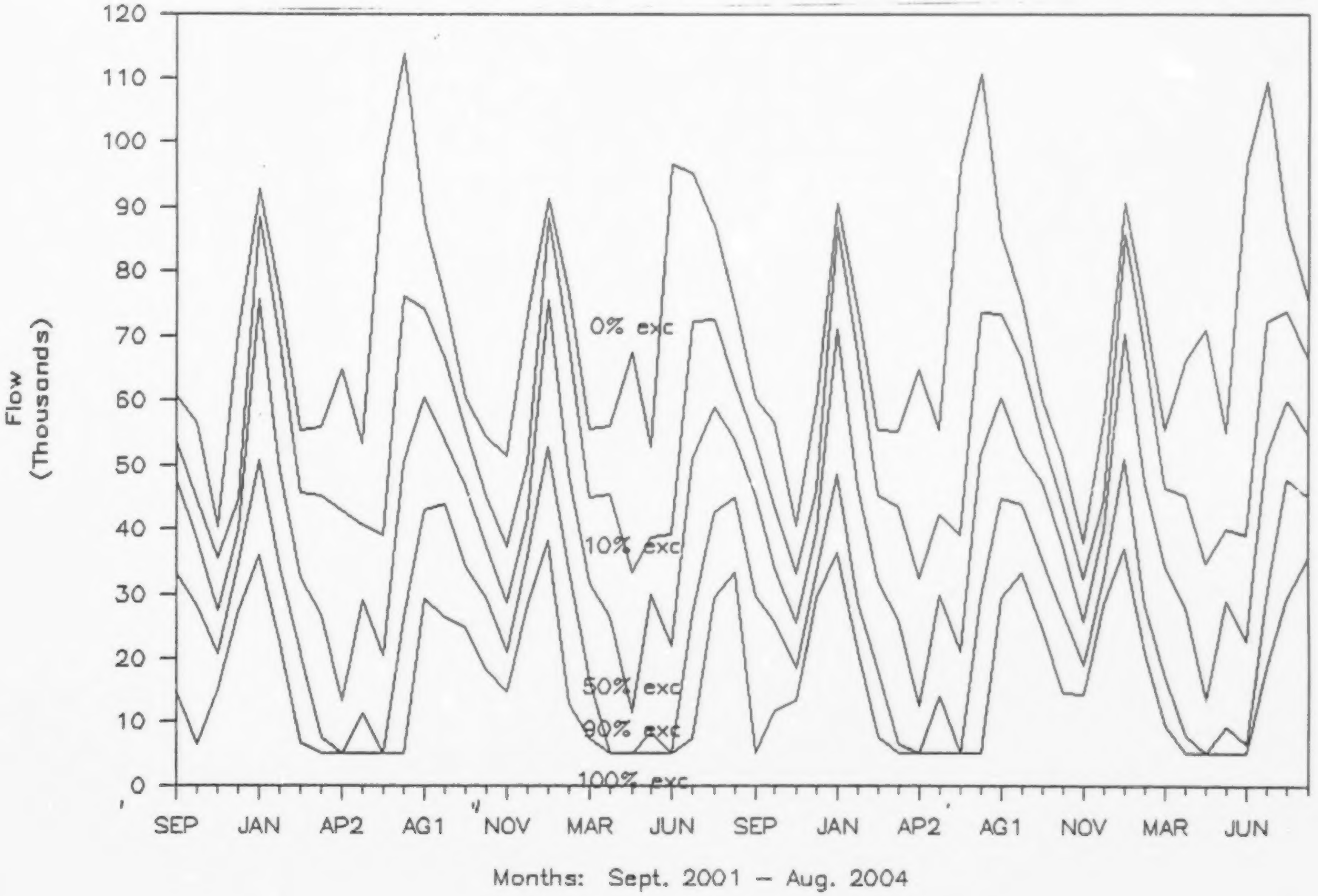
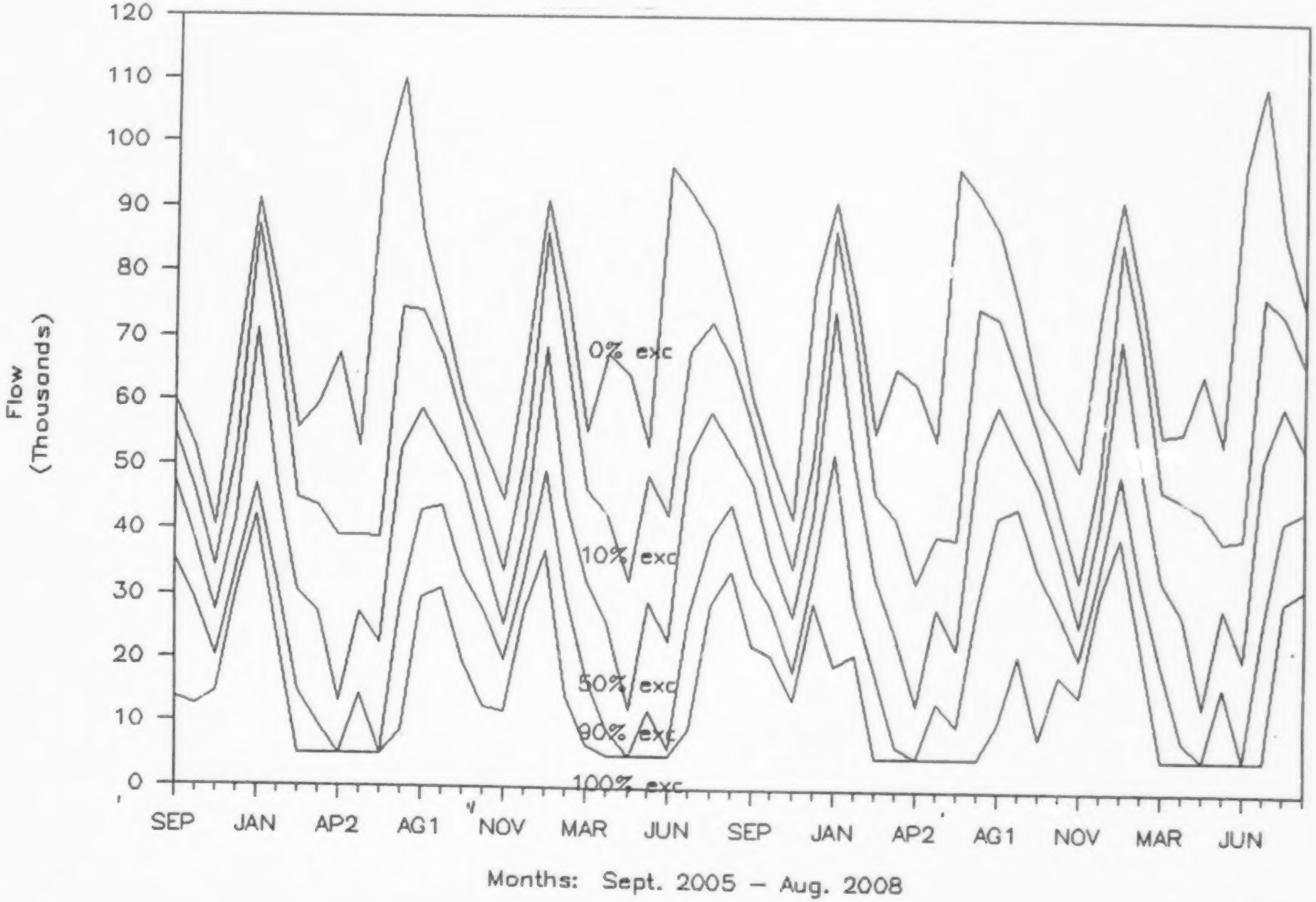


Figure A7.2.20 Flows at Arrow Lakes Reservoir, Regime 1 (Medium Load): September 2005 - August 2008



APPENDIX 7.3

Regime 2 (Medium Load)

Figure A7.3.1 Elevations at Mica Reservoir, Regime 2 (Medium Load): September 1989 - August 1992

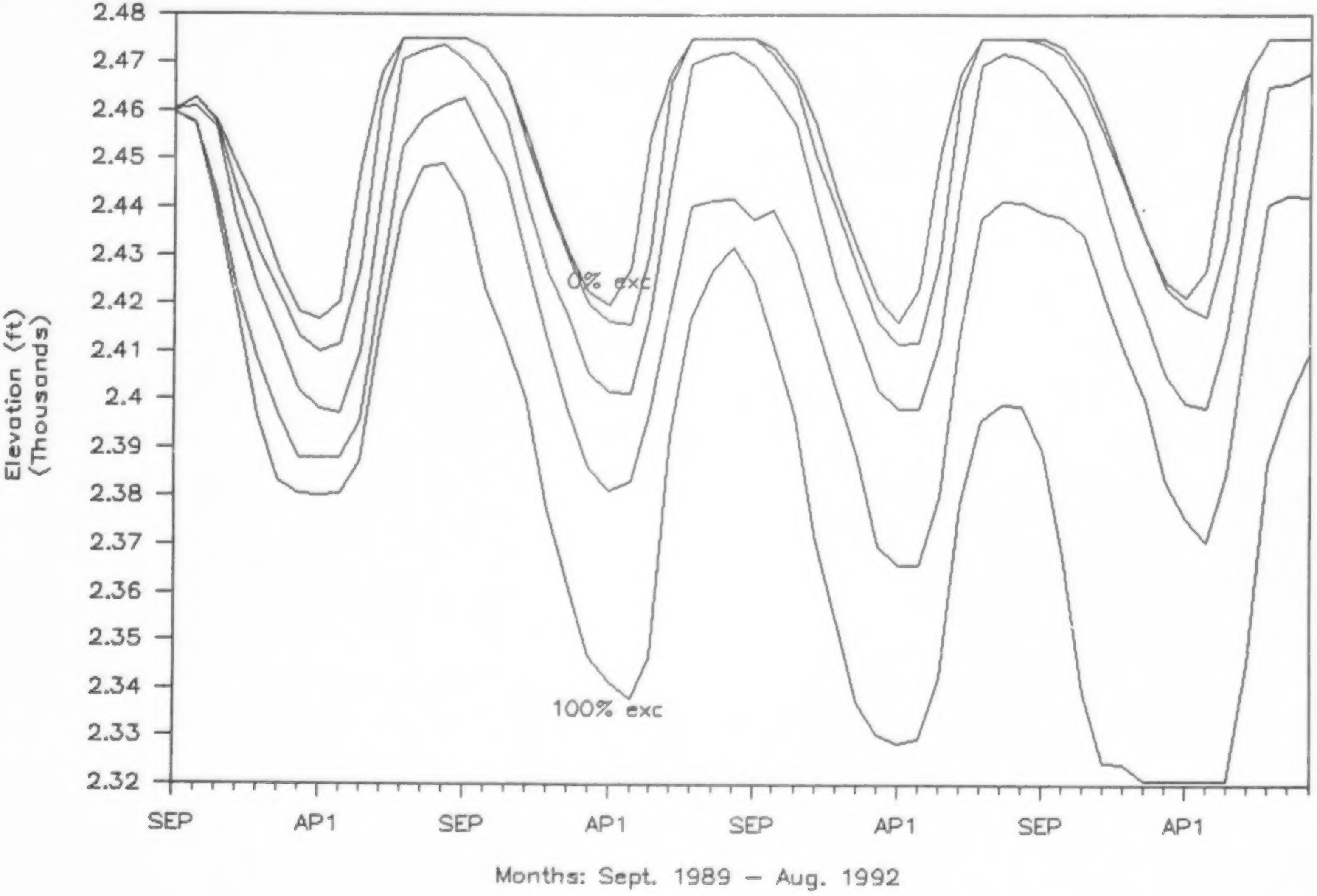


Figure A7.3.2 Elevations at Mica Reservoir, Regime 2 (Medium Load): September 1993 - August 1996

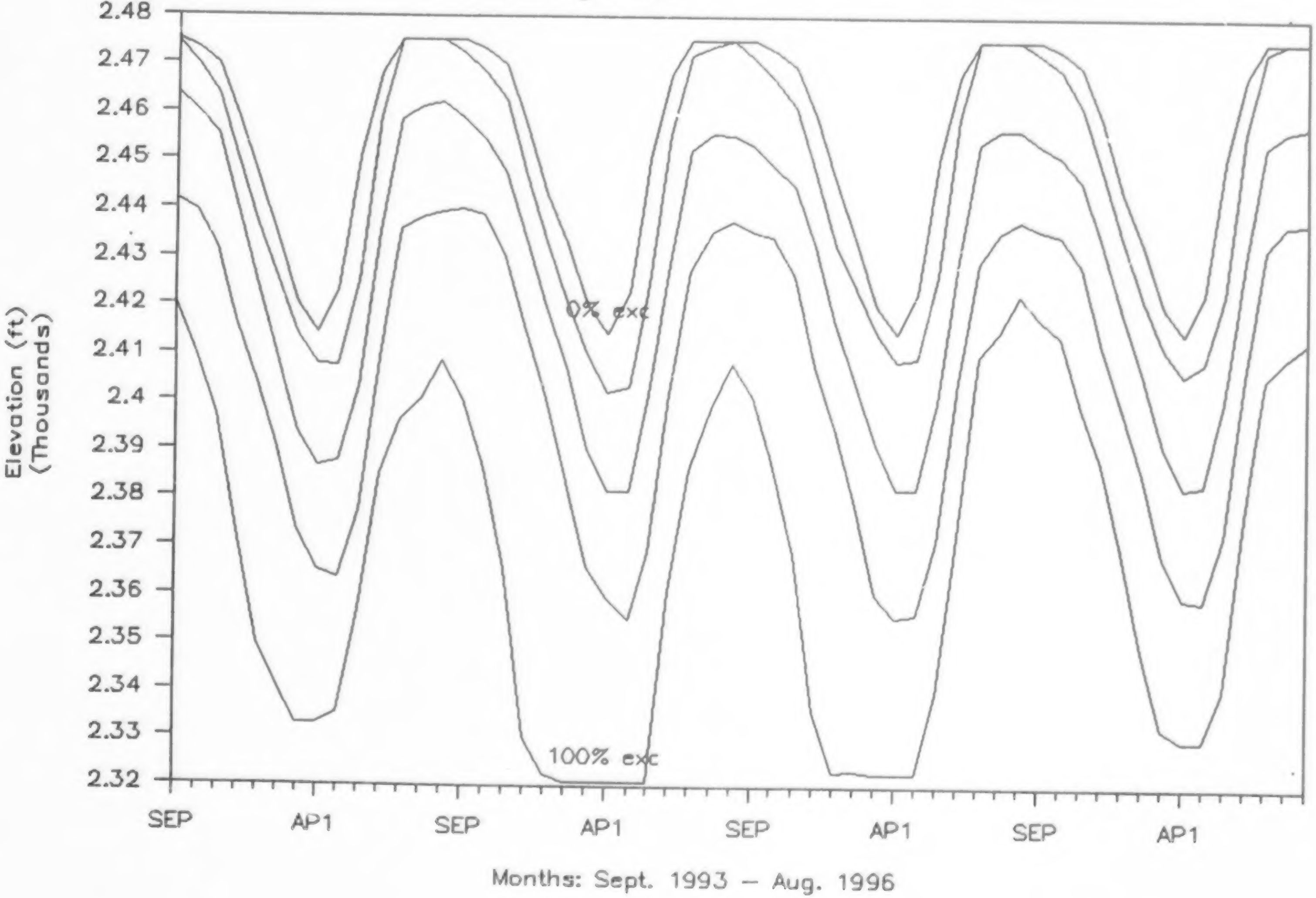


Figure A7.3.3 Elevations at Mica Reservoir, Regime 2 (Medium Load): September 1997 - August 2000

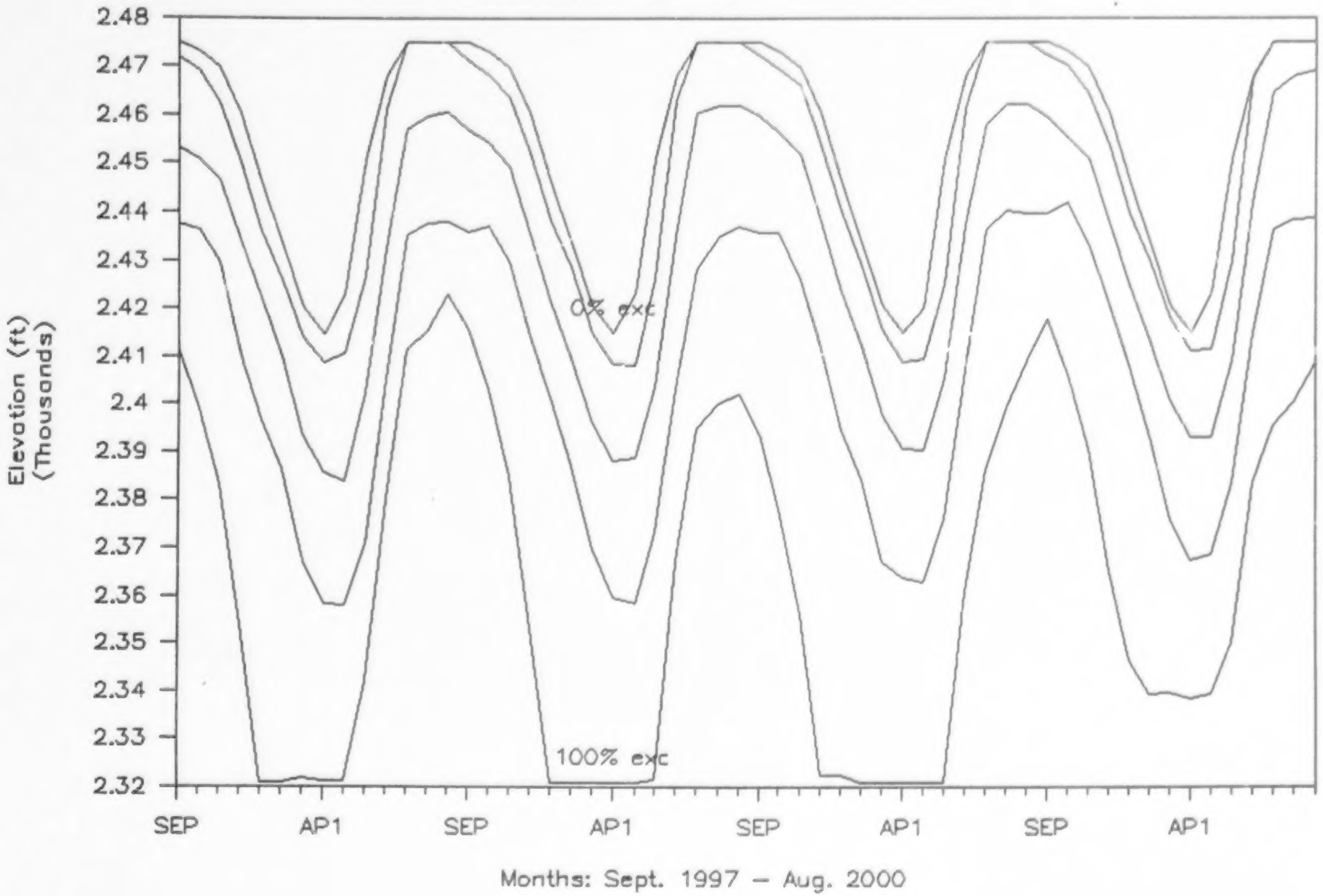


Figure A7.3.4 Elevations at Mica Reservoir, Regime 2 (Medium Load): September 2001 - August 2004

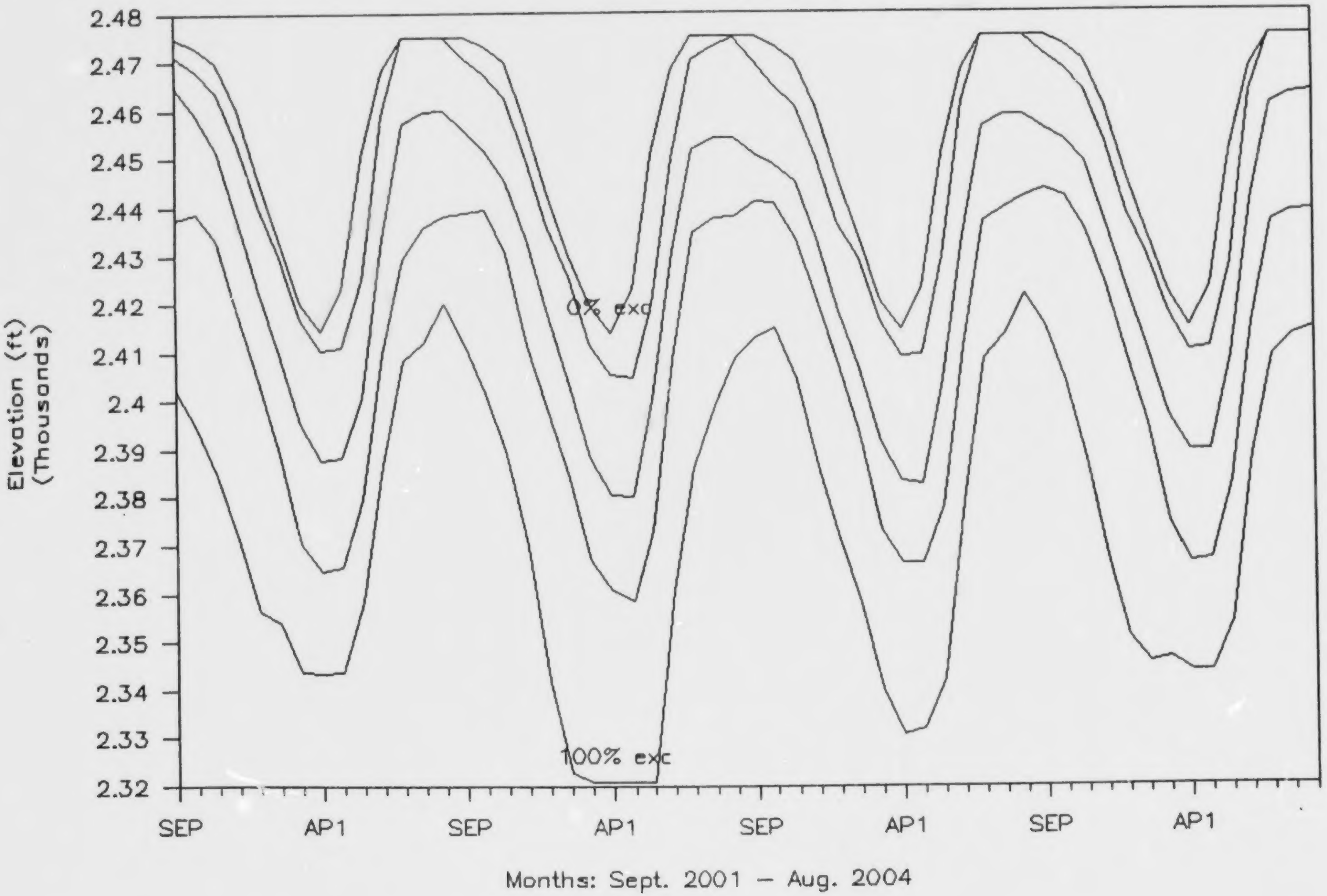


Figure A7.3.5 Elevations at Mica Reservoir, Regime 2 (Medium Load): September 2005 - August 2008

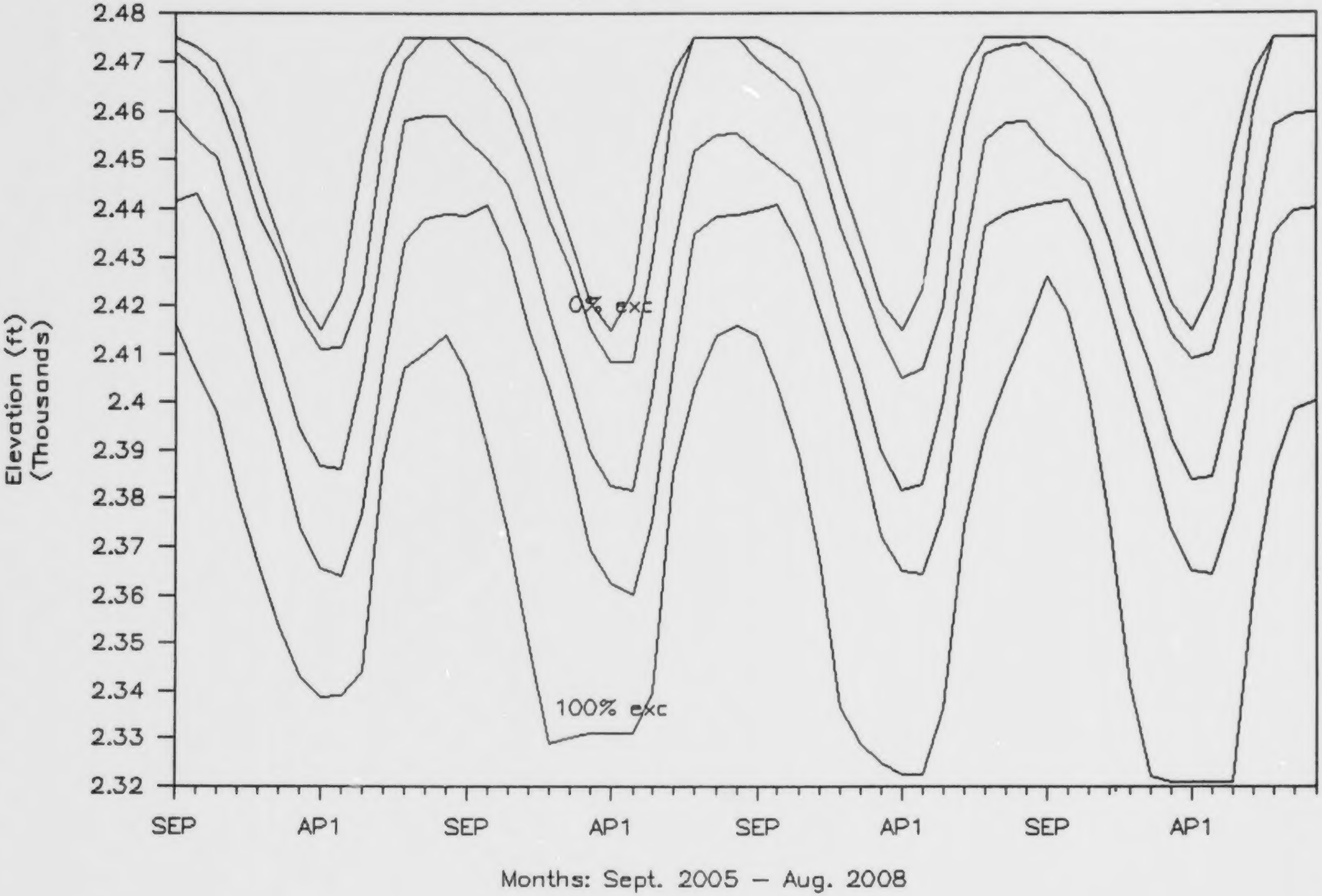


Figure A7.3.6 Flows at Mica Reservoir, Regime 2 (Medium Load): September 1989 - August 1992

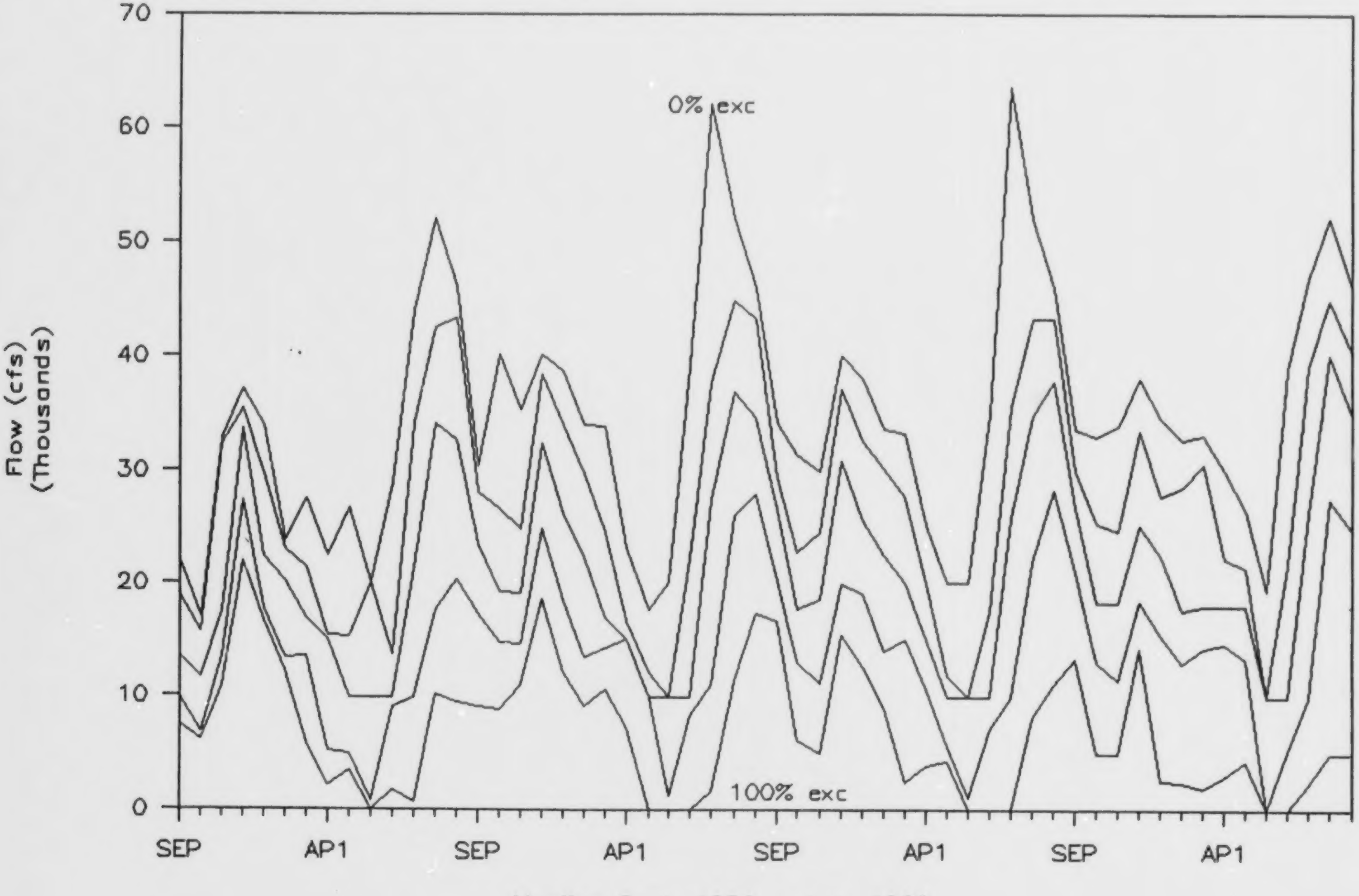


Figure A7.3.7 Flows at Mica Reservoir, Regime 2 (Medium Load): September 1993 - August 1996

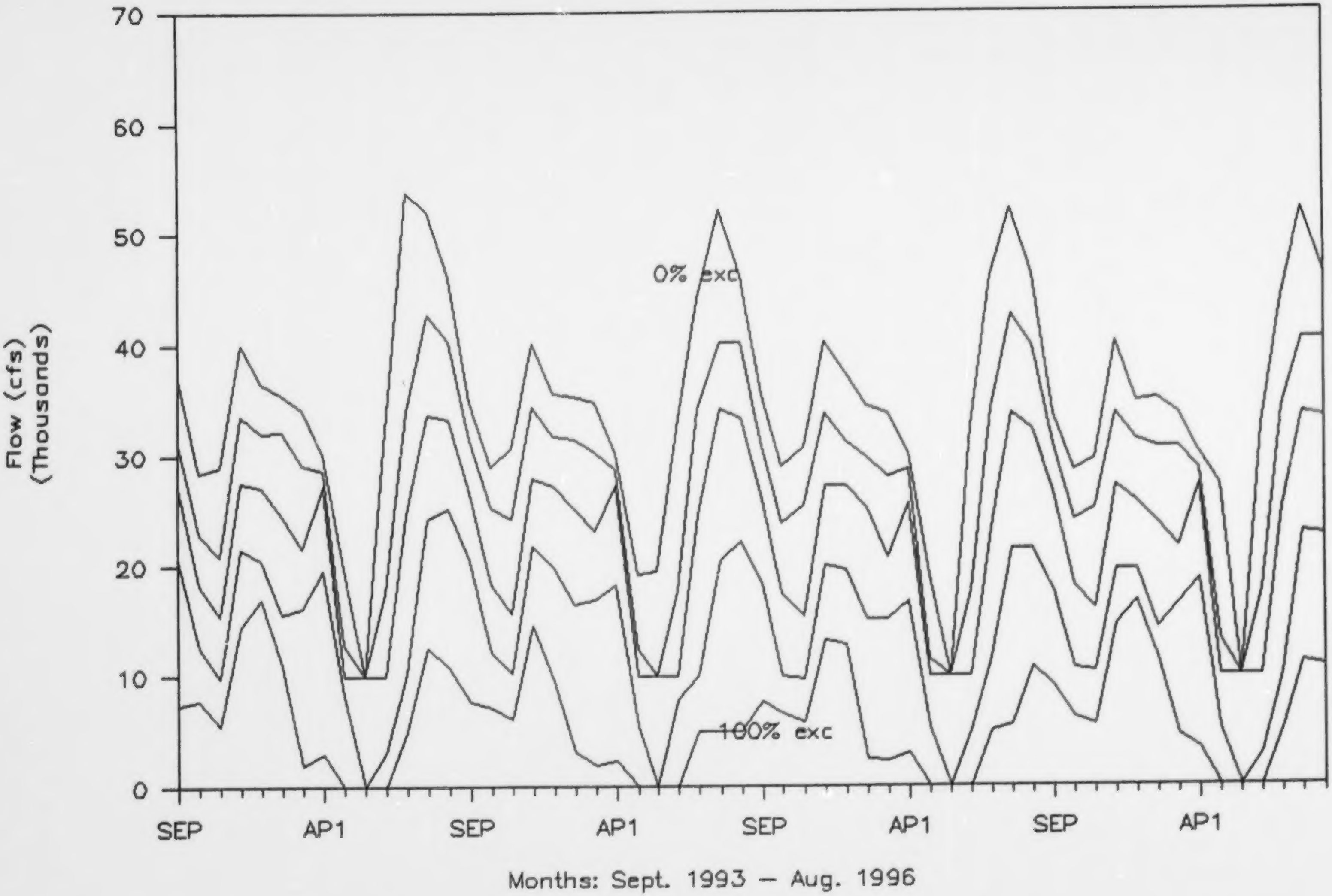


Figure A7.3.8 Flows at Mica Reservoir, Regime 2 (Medium Load): September 1997 - August 2000

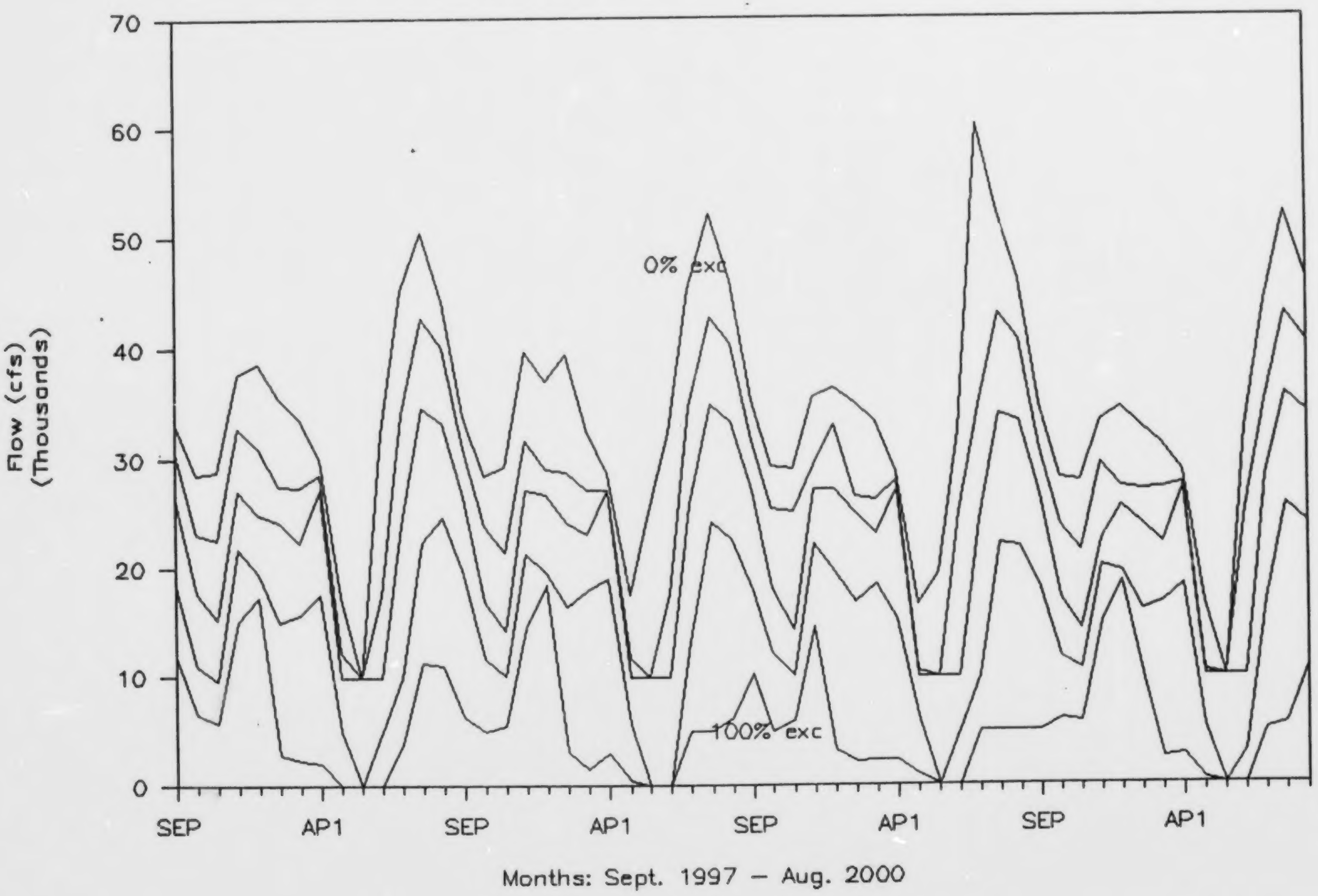


Figure A7.3.9 Flows at Mica Reservoir, Regime 2 (Medium Load): September 2001 - August 2004

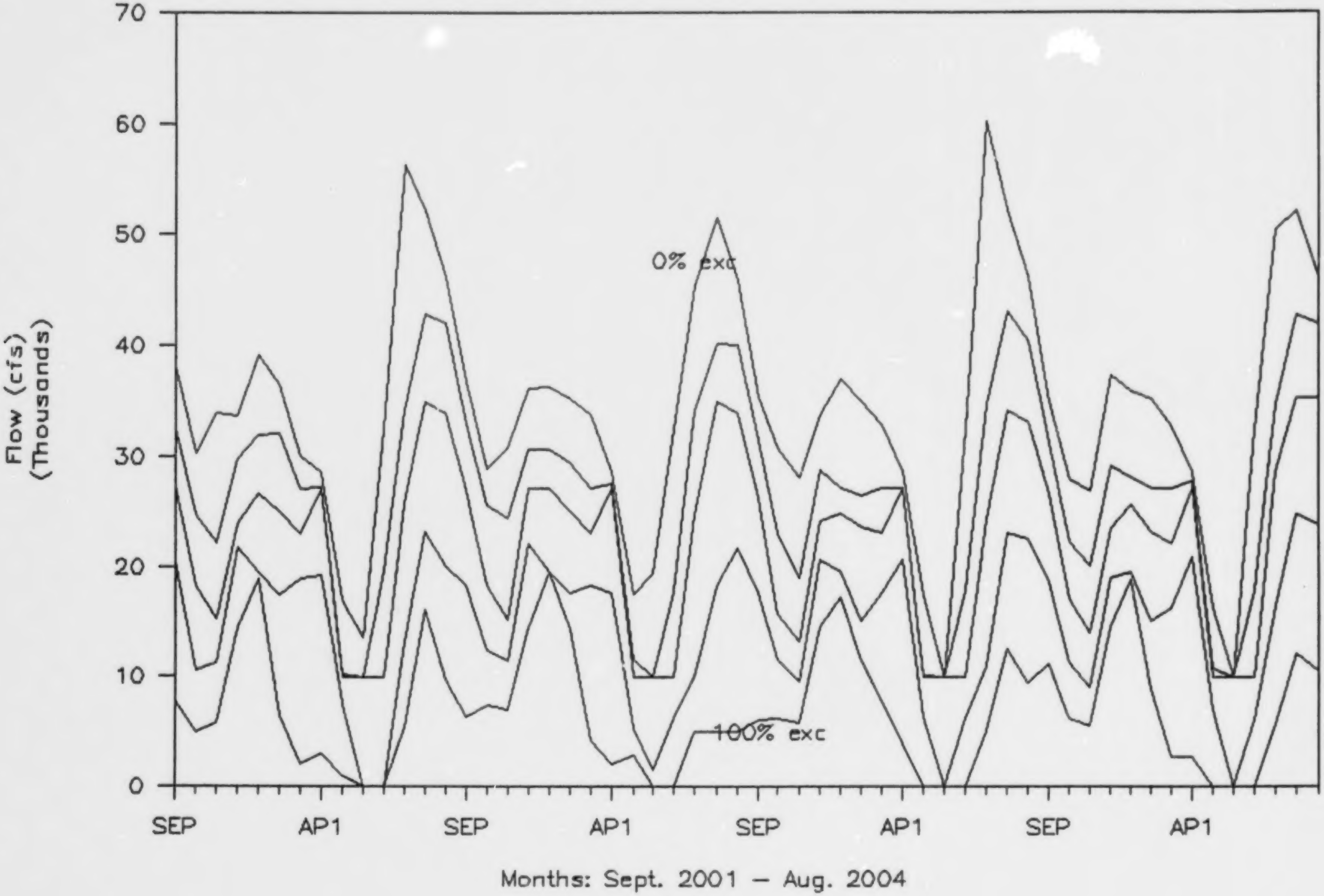


Figure A7.3.10 Flows at Mica Reservoir, Regime 2 (Medium Load): September 2005 - August 2008

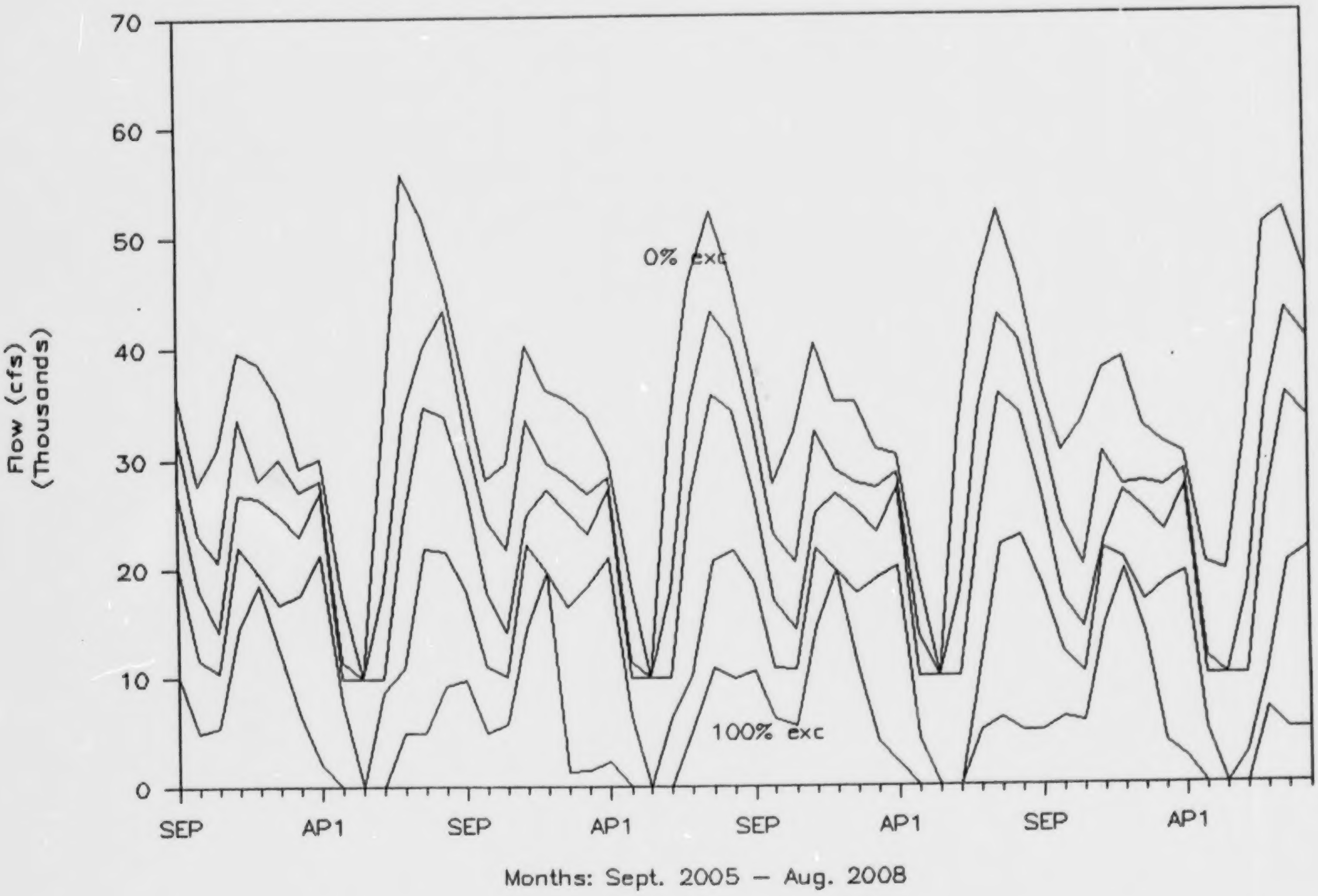


Figure A7.3.11 Elevations at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 1989 - August 1992

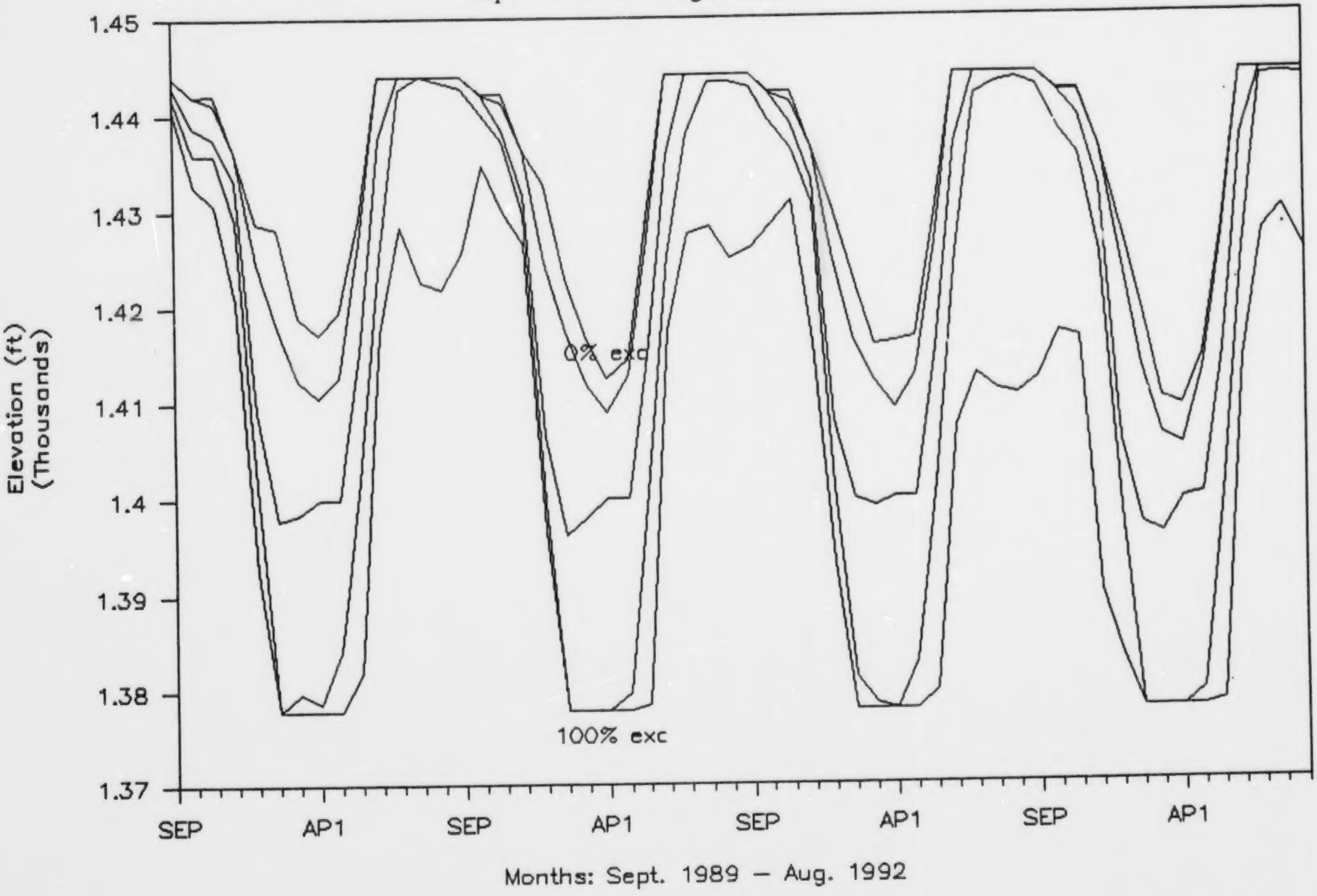


Figure A7.3.12 Elevations at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 1993 - August 1996

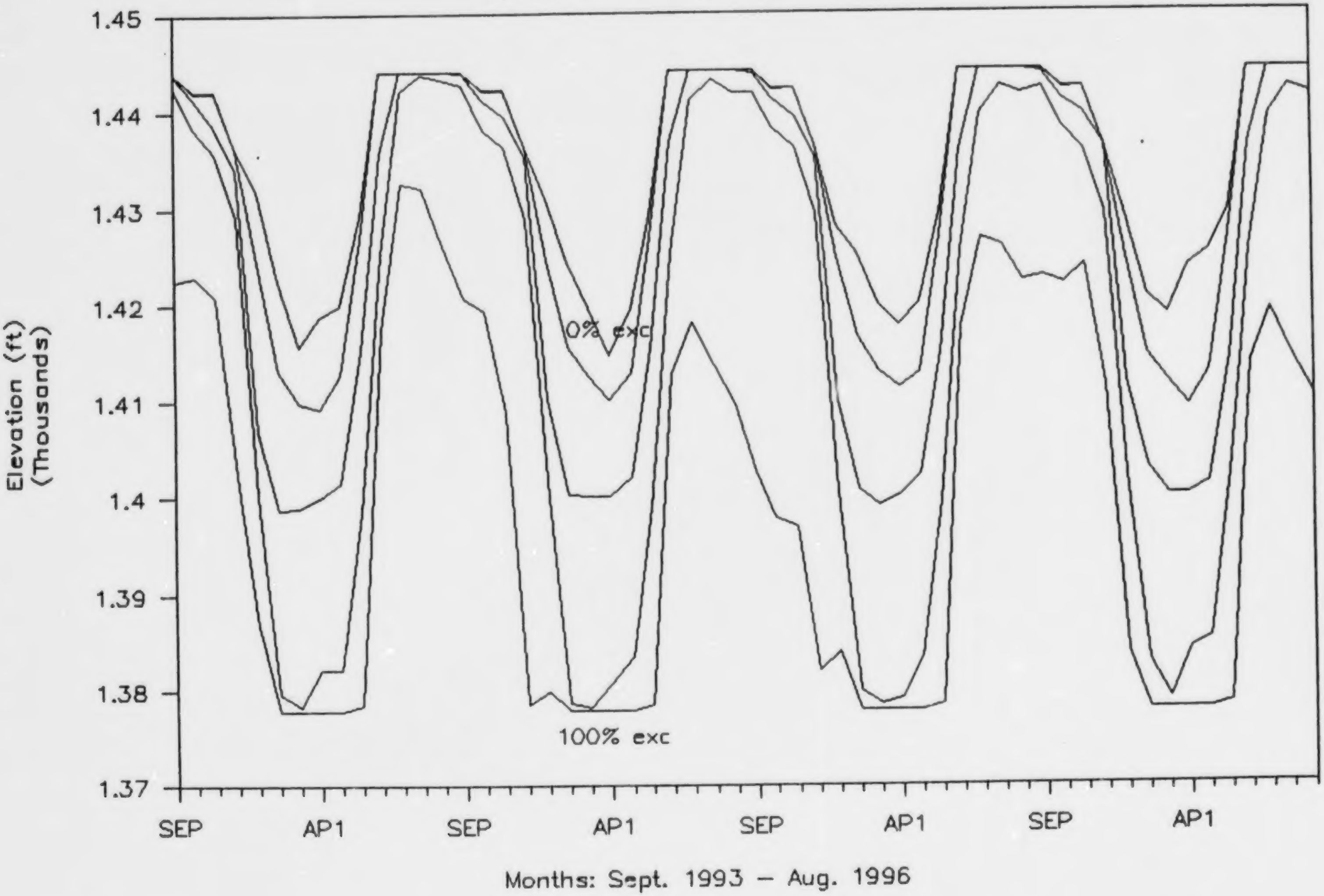


Figure A7.3.13 Elevations at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 1997 - August 2000

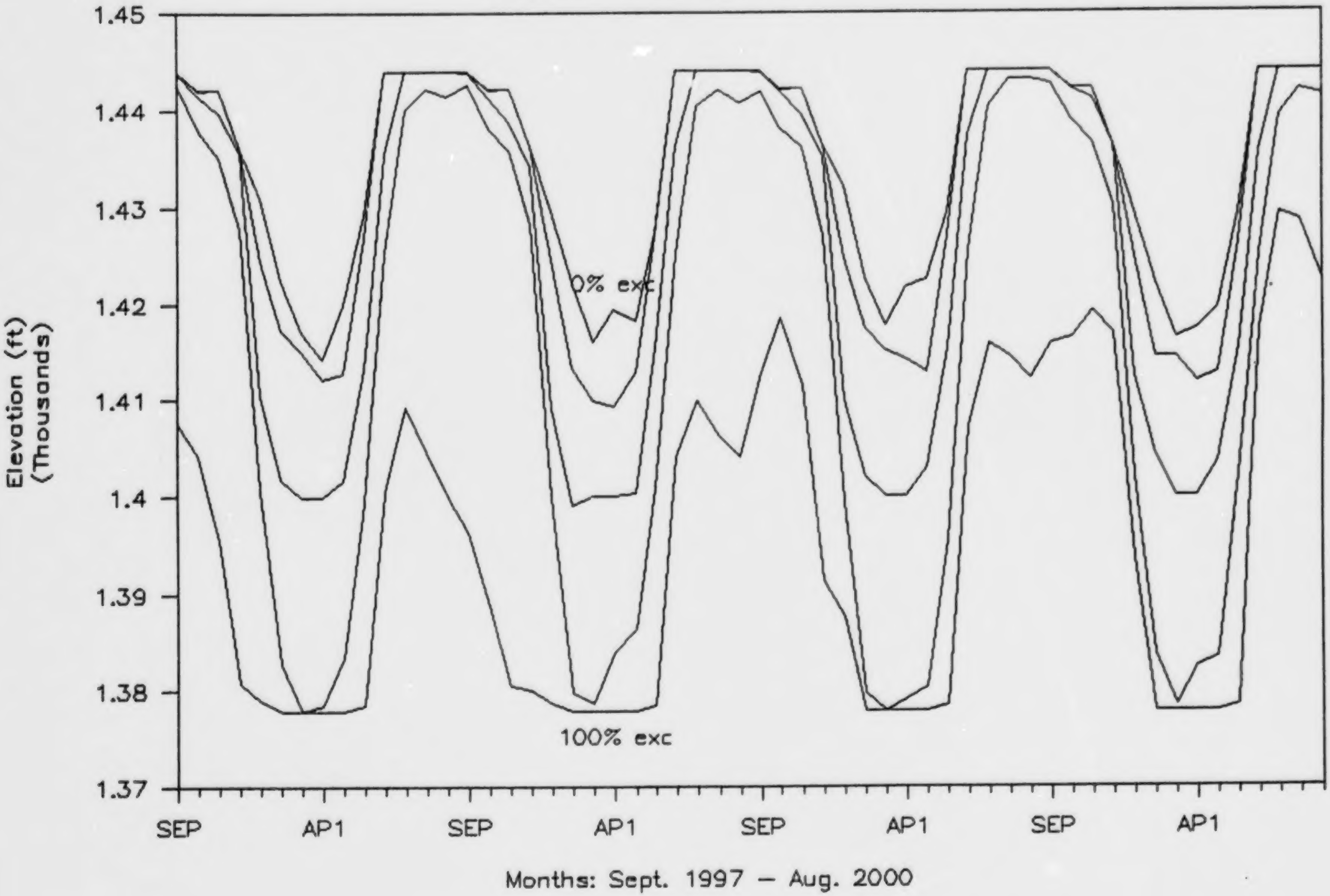


Figure A7.3.14 Elevations at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 2001 - August 2004

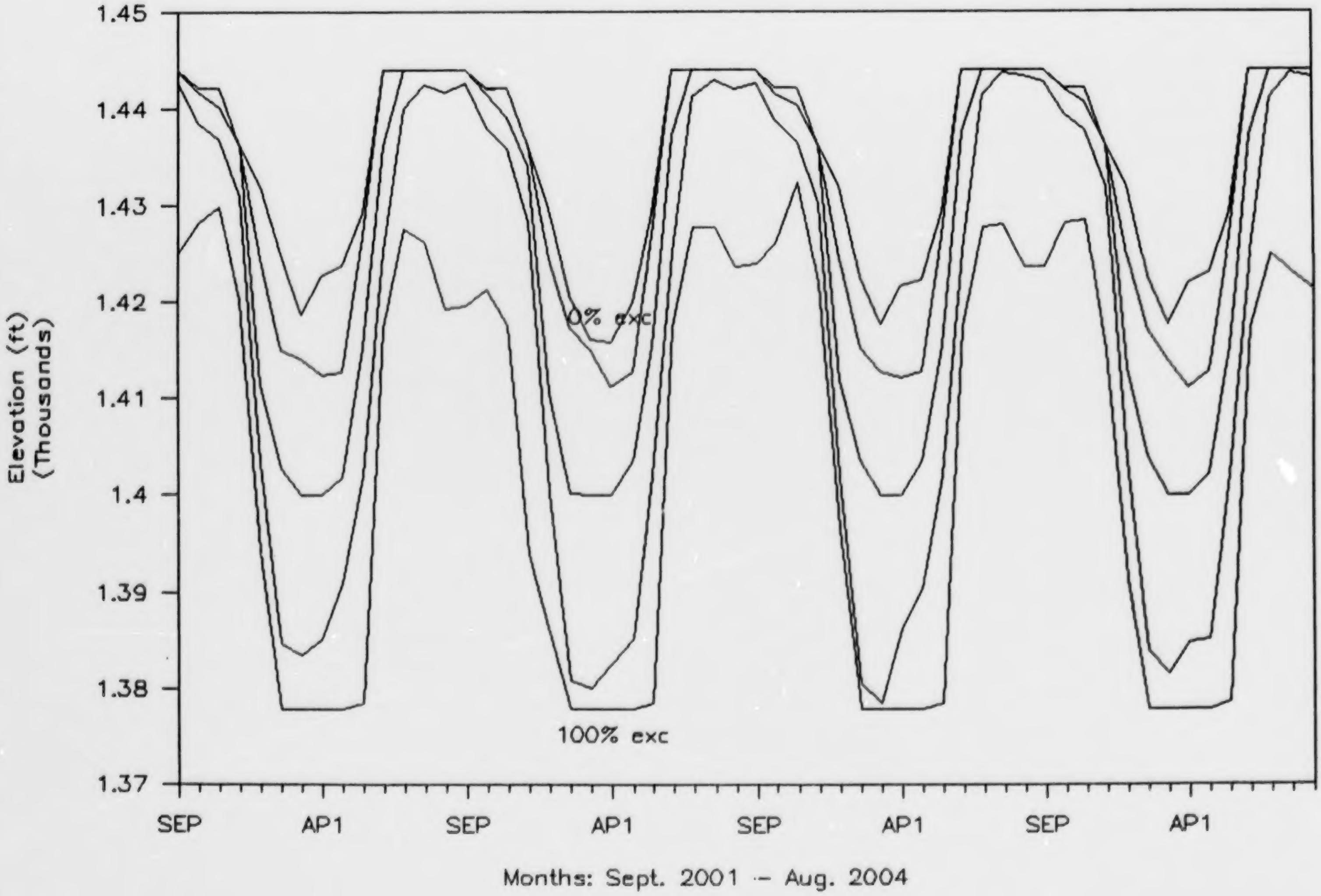


Figure A7.3.15 Elevations at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 2005 - August 2008

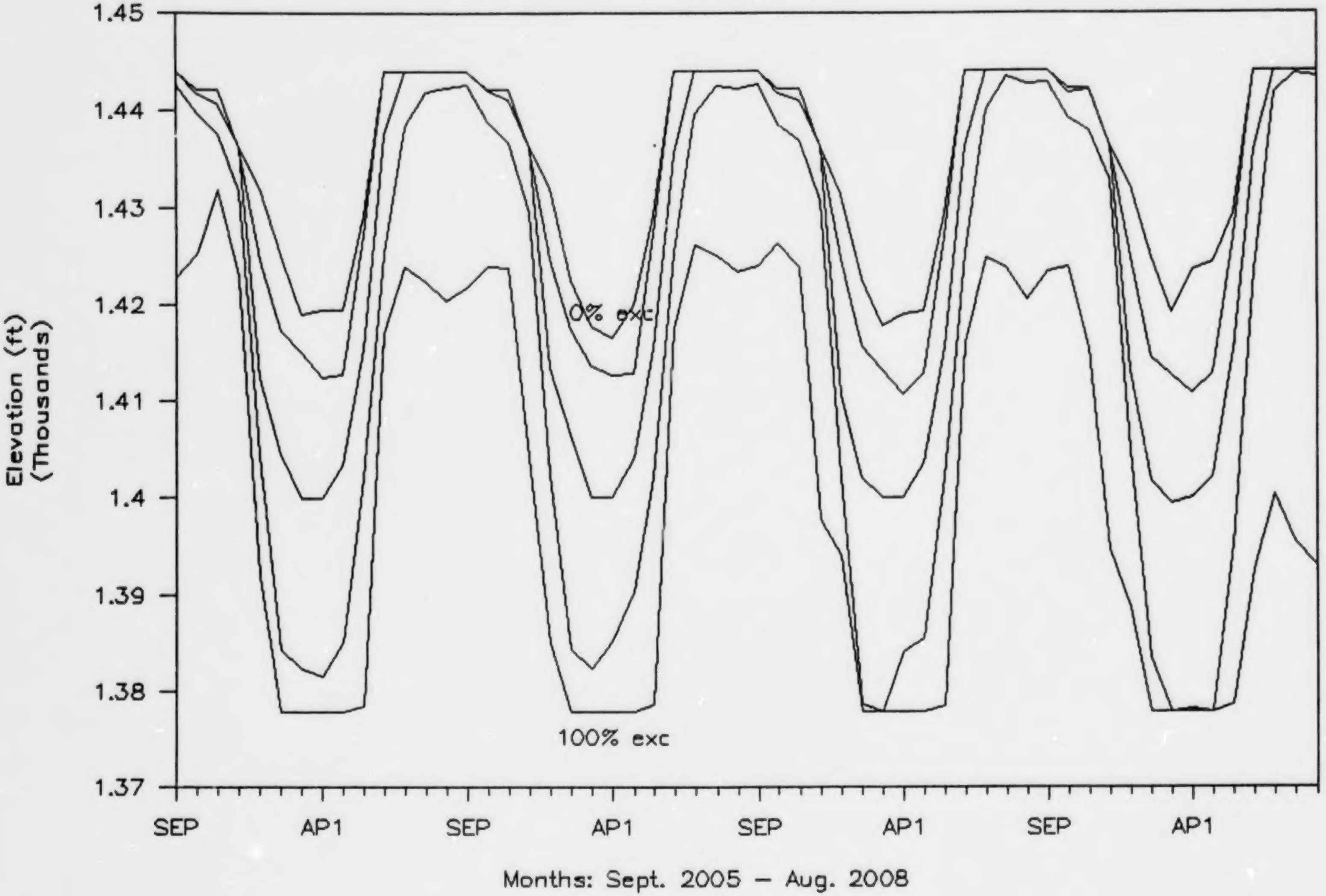


Figure A7.3.16 Flows at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 1989 - August 1992

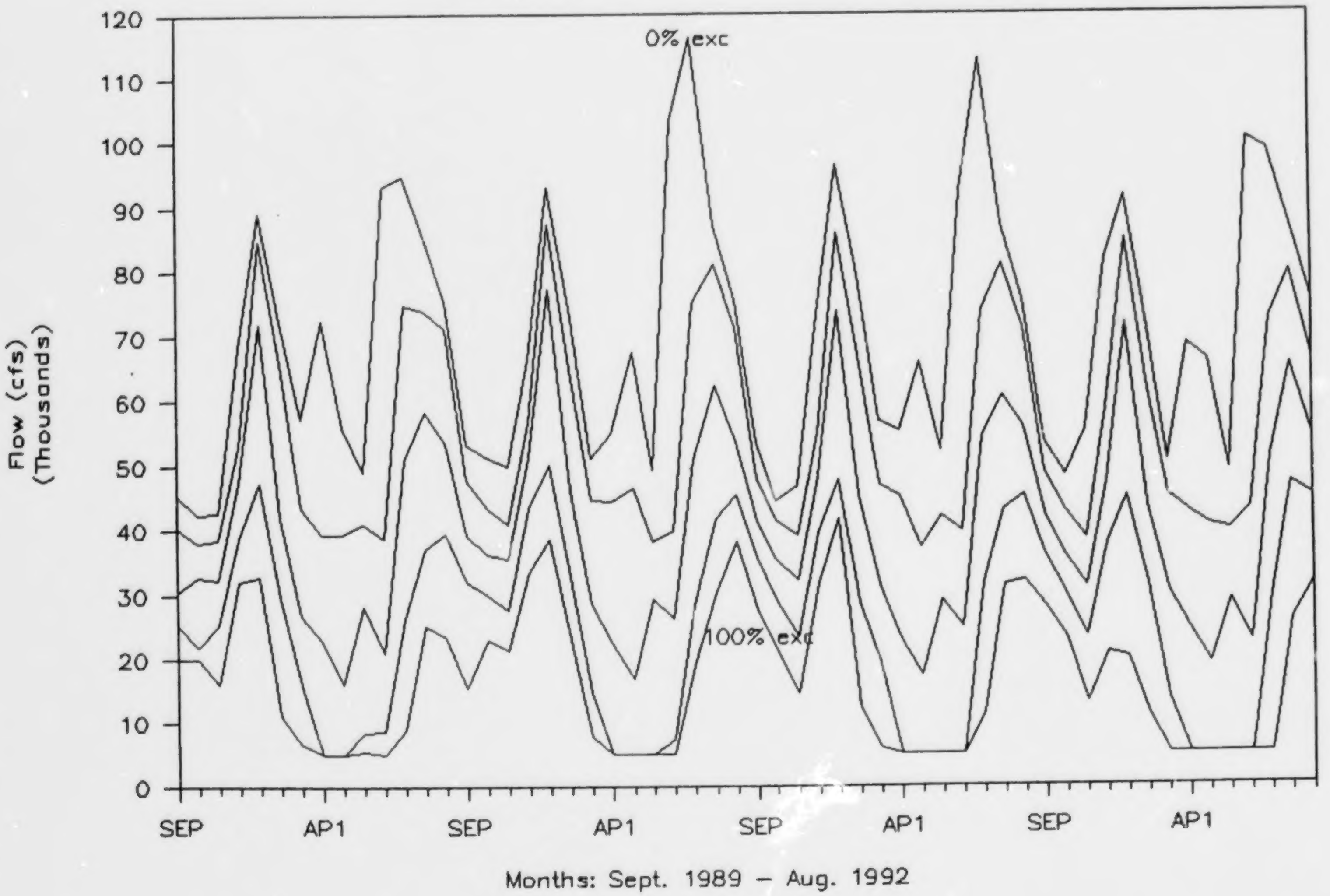


Figure A7.3.17 Flows at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 1993 - August 1996

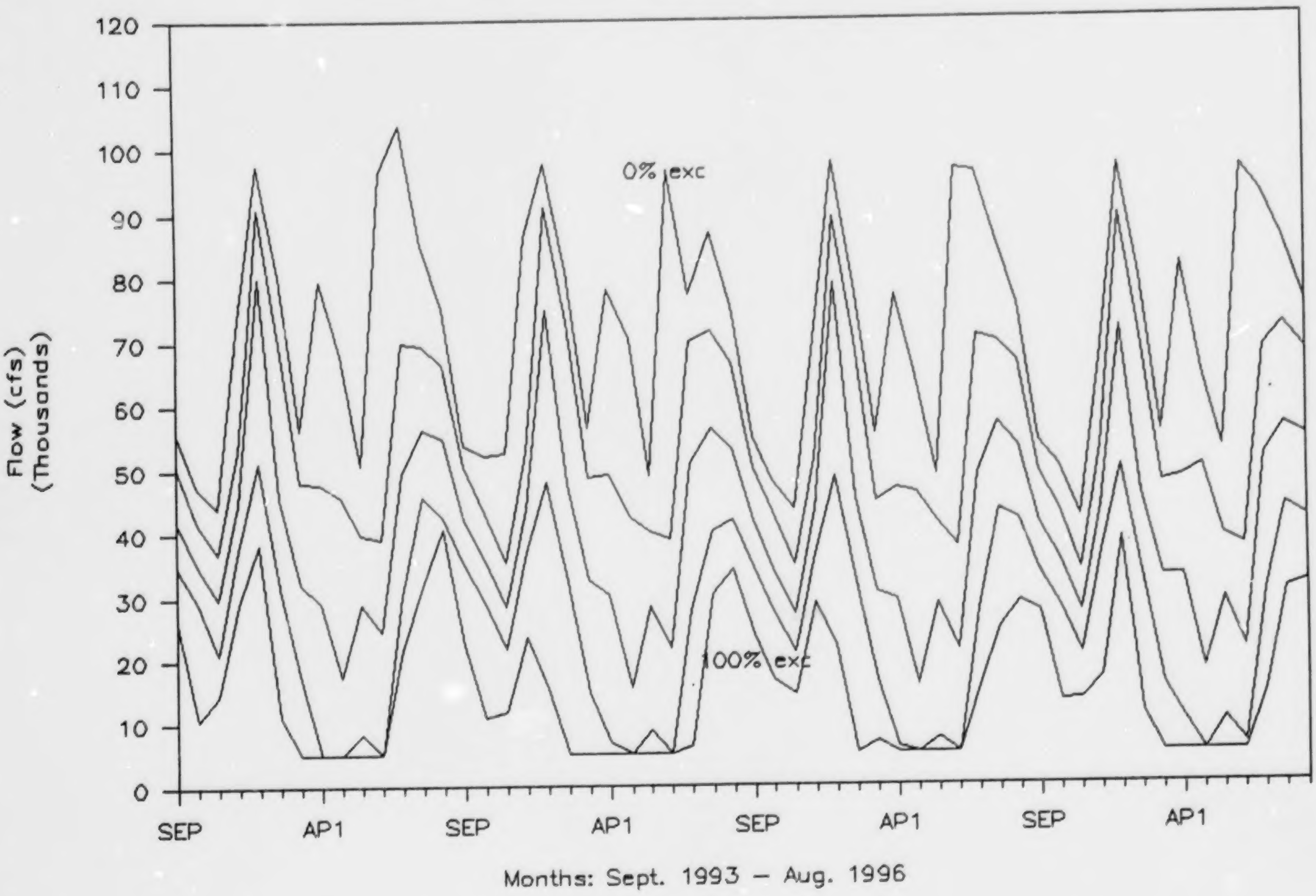


Figure A7.3.18 Flows at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 1997 - August 2000

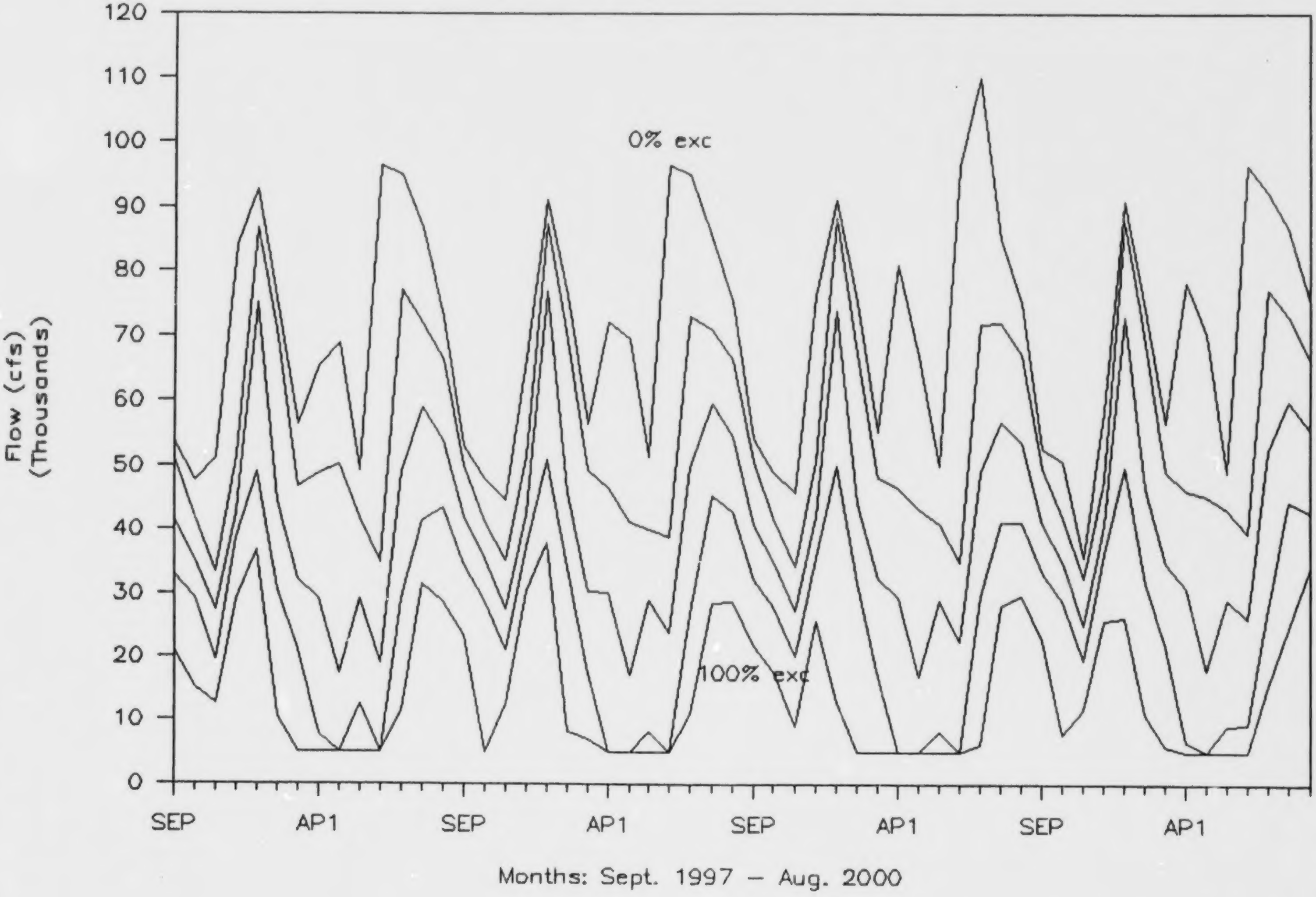


Figure A7.3.19 Flows at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 2001 - August 2004

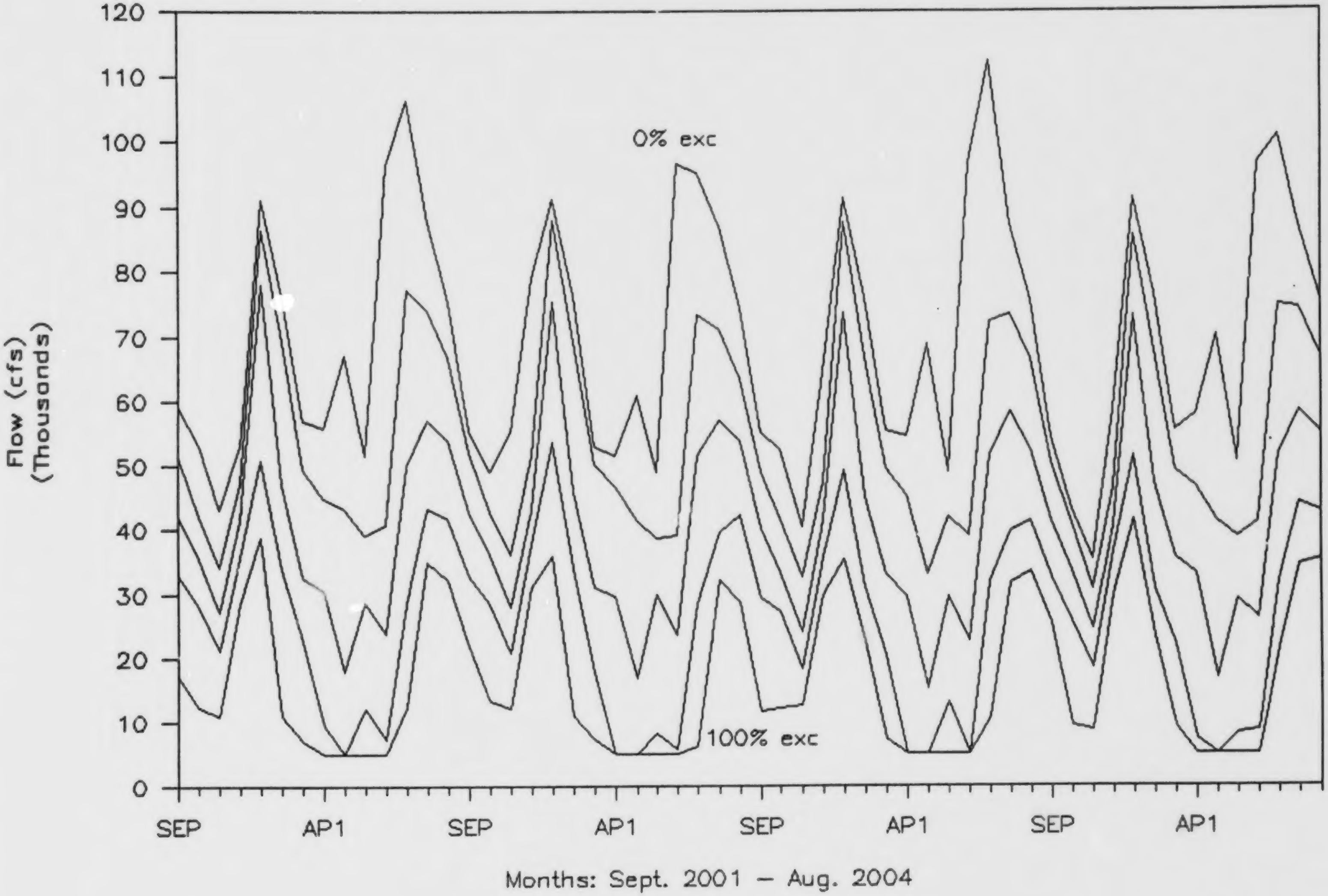
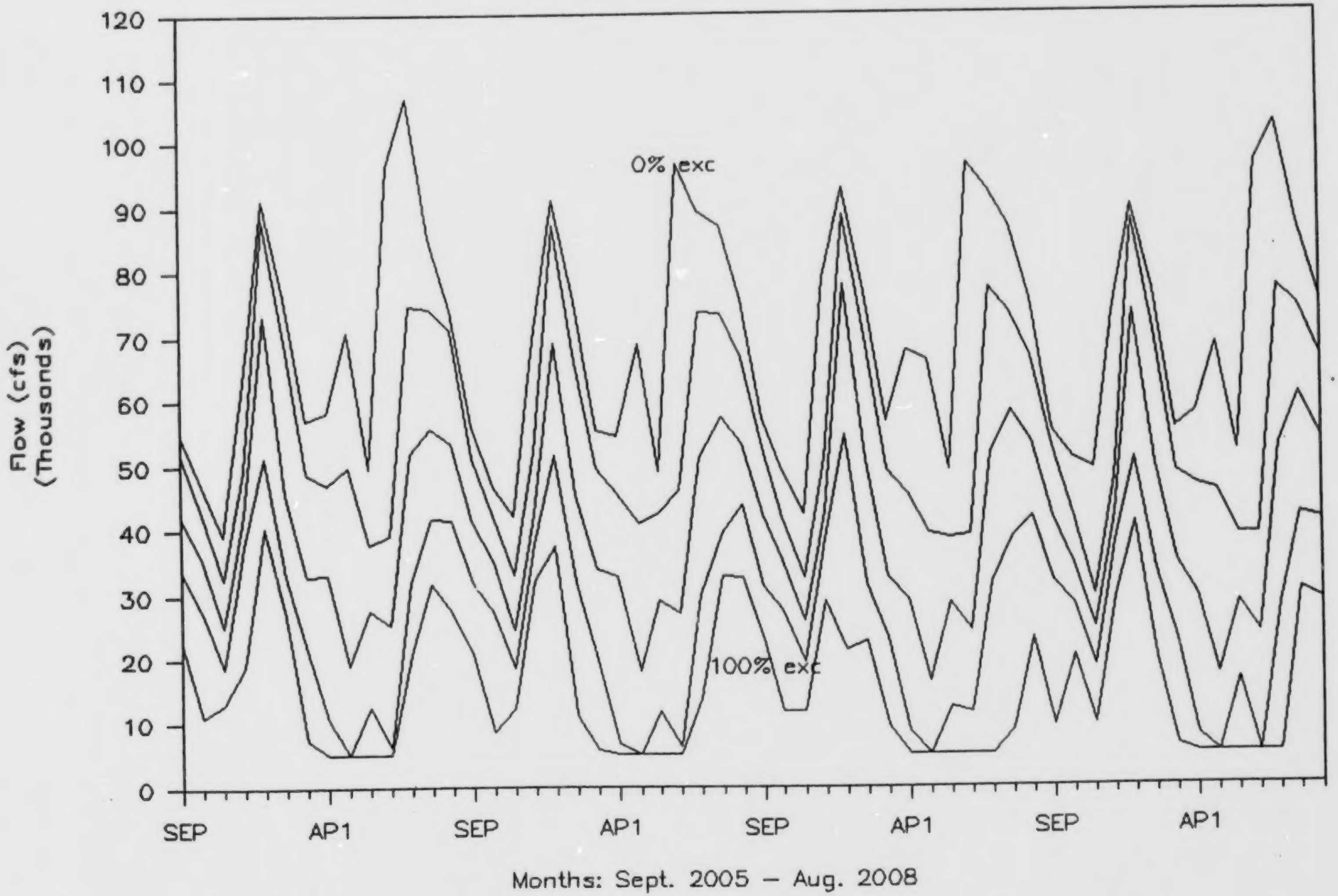


Figure A7.3.20 Flows at Arrow Lakes Reservoir, Regime 2 (Medium Load): September 2005 - August 2008



APPENDIX 8

Alternate Resource Order (ARO) Energy Load Scenario Summary Hydrographs

1989 - 2008

8.1 Base Case (ARO)
8.2 Regime 1 (ARO)

APPENDIX 8.1

Base Case (ARO)

Figure A8.1.1 Elevations at Mica Reservoir, Base Case (ARO): September 1989 - August 1992

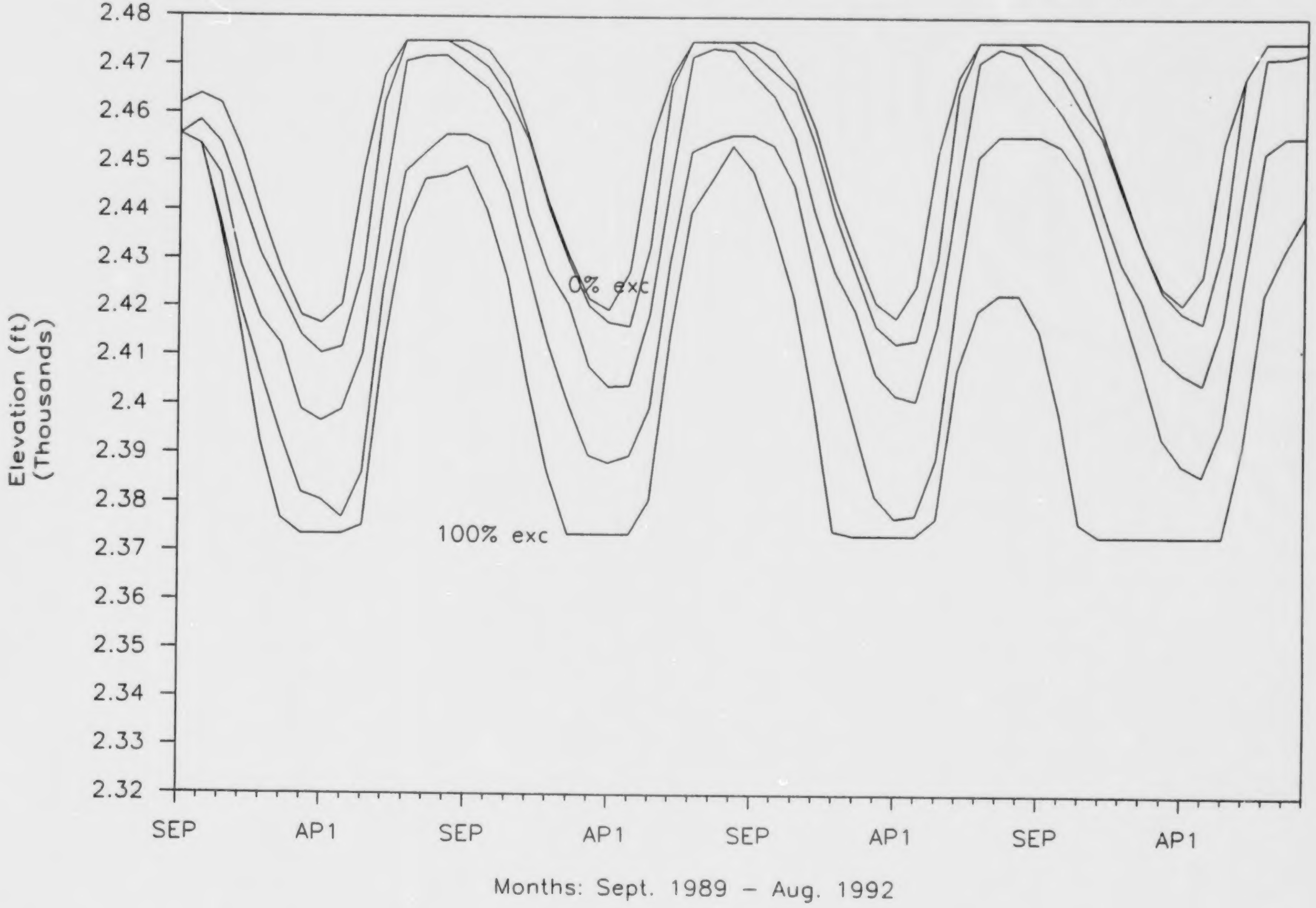


Figure A8.1.2 Elevations at Mica Reservoir, Base Case (ARO): September 1993 - August 1996

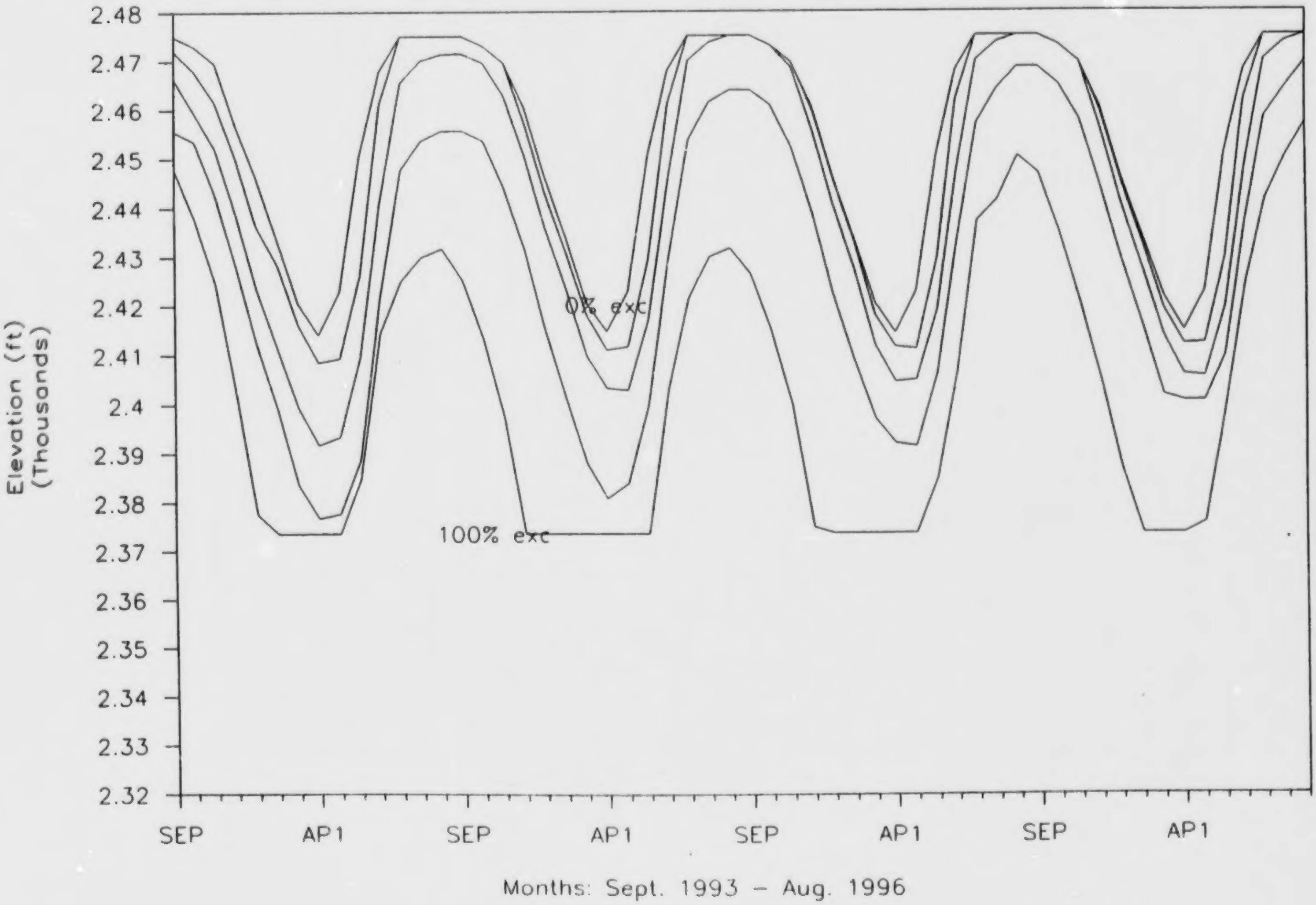


Figure A8.1.3 Elevations at Mica Reservoir, Base Case (ARO): September 1997 - August 2000

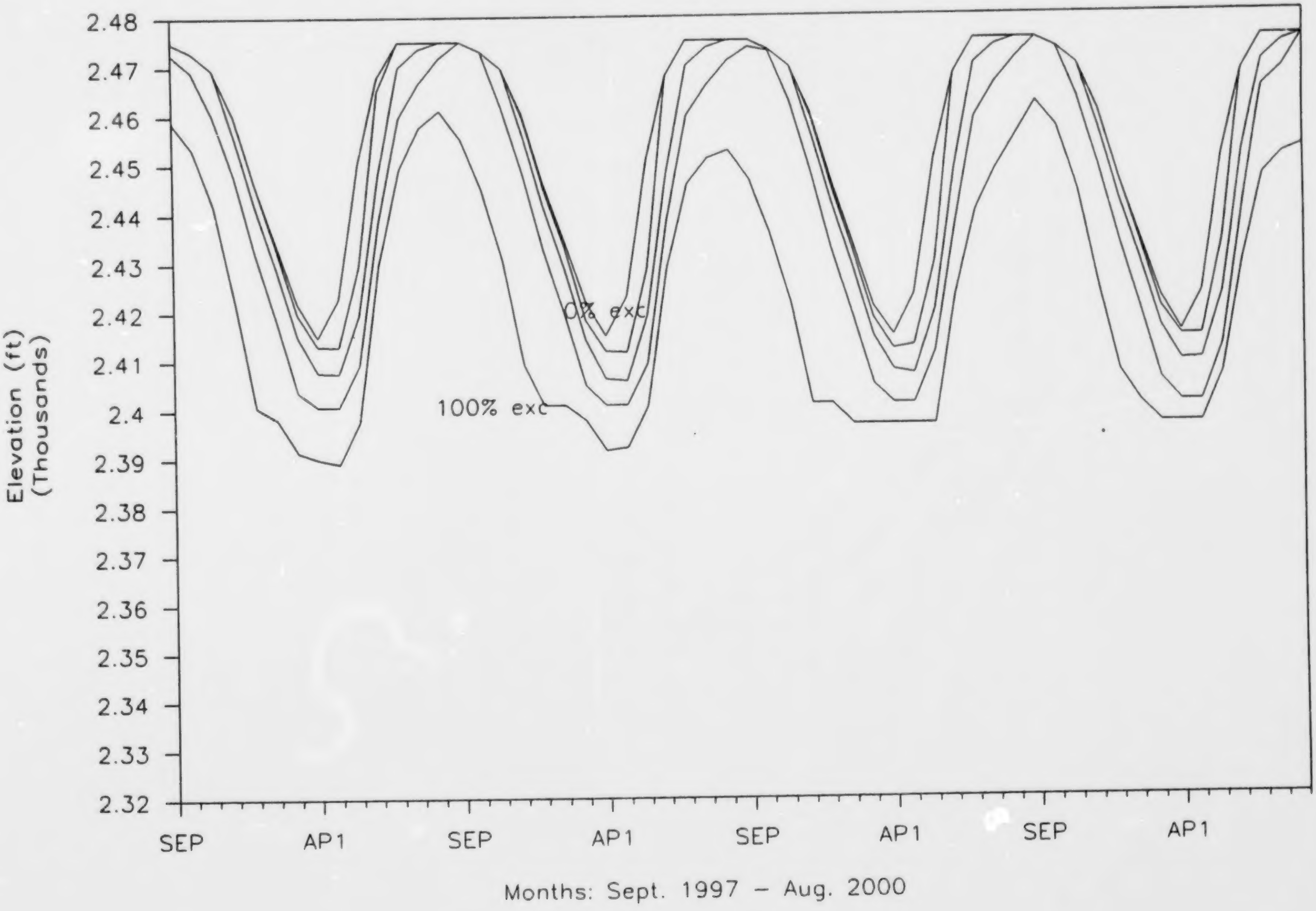


Figure A8.1.4 Elevations at Mica Reservoir, Base Case (ARO): September 2001 - August 2004

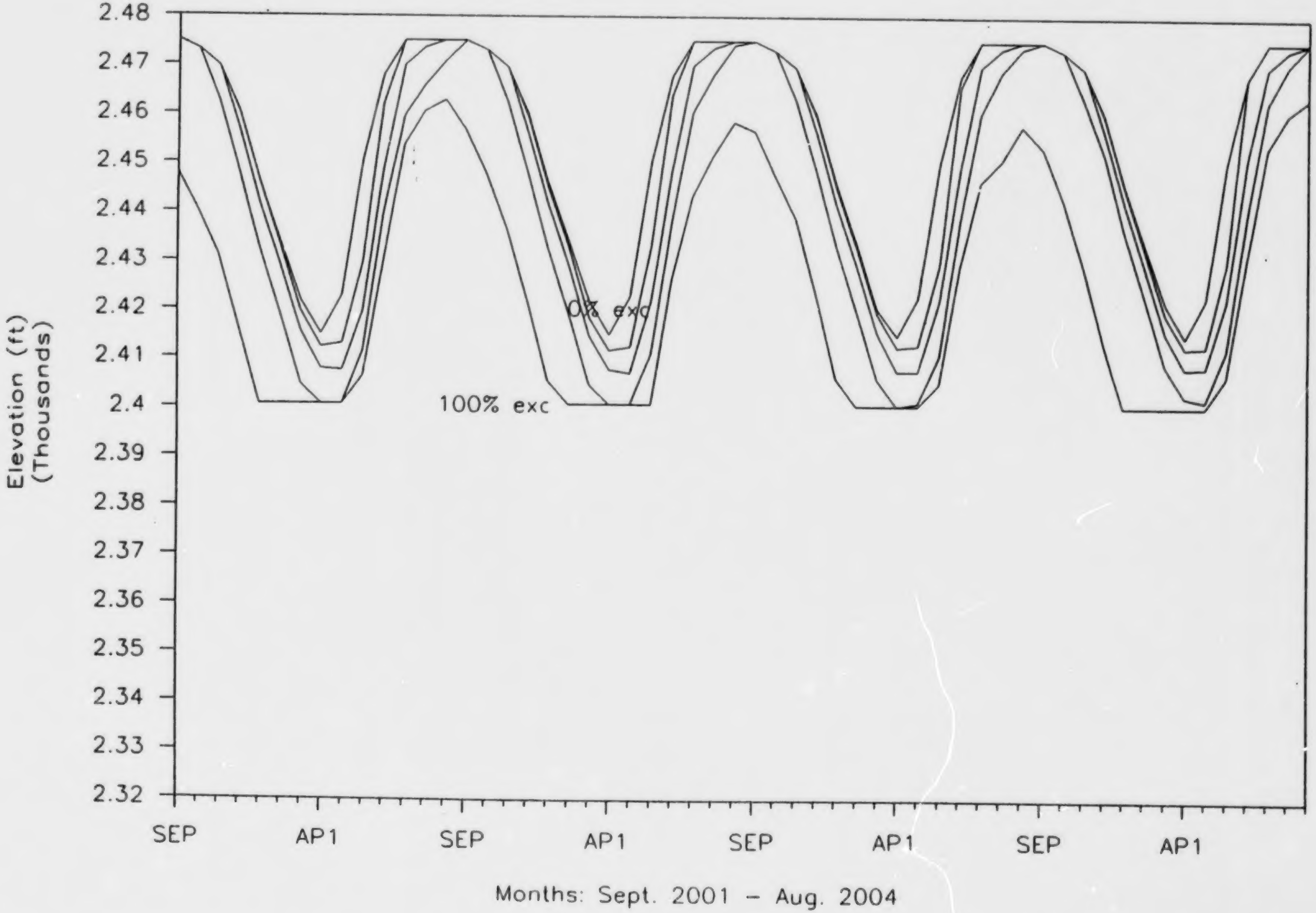


Figure A8.1.5 Elevations at Mica Reservoir, Base Case (ARO): September 2005 - August 2008

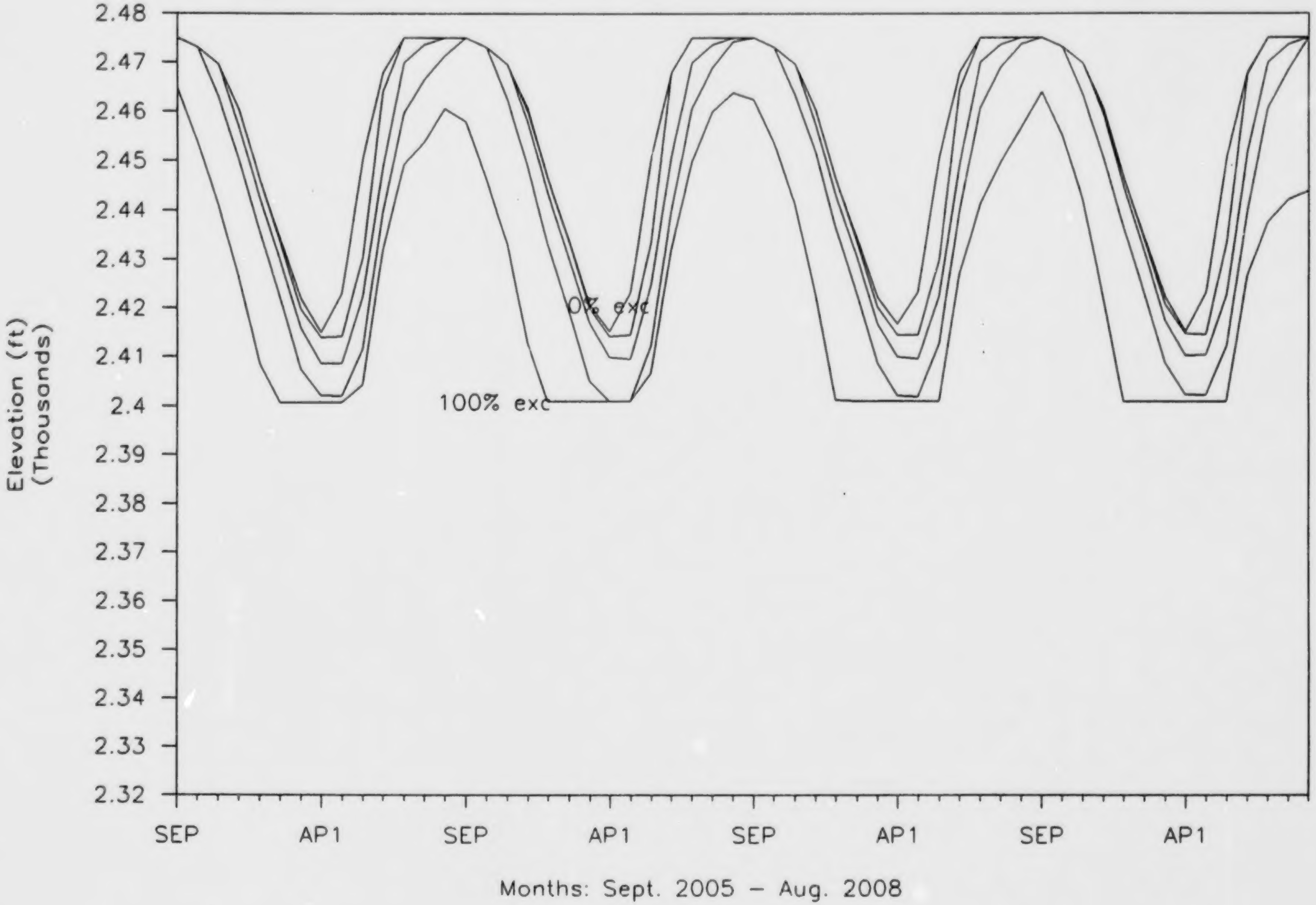


Figure A8.1.6 Flows at Mica Reservoir, Base Case (ARO): September 1989 - August 1992

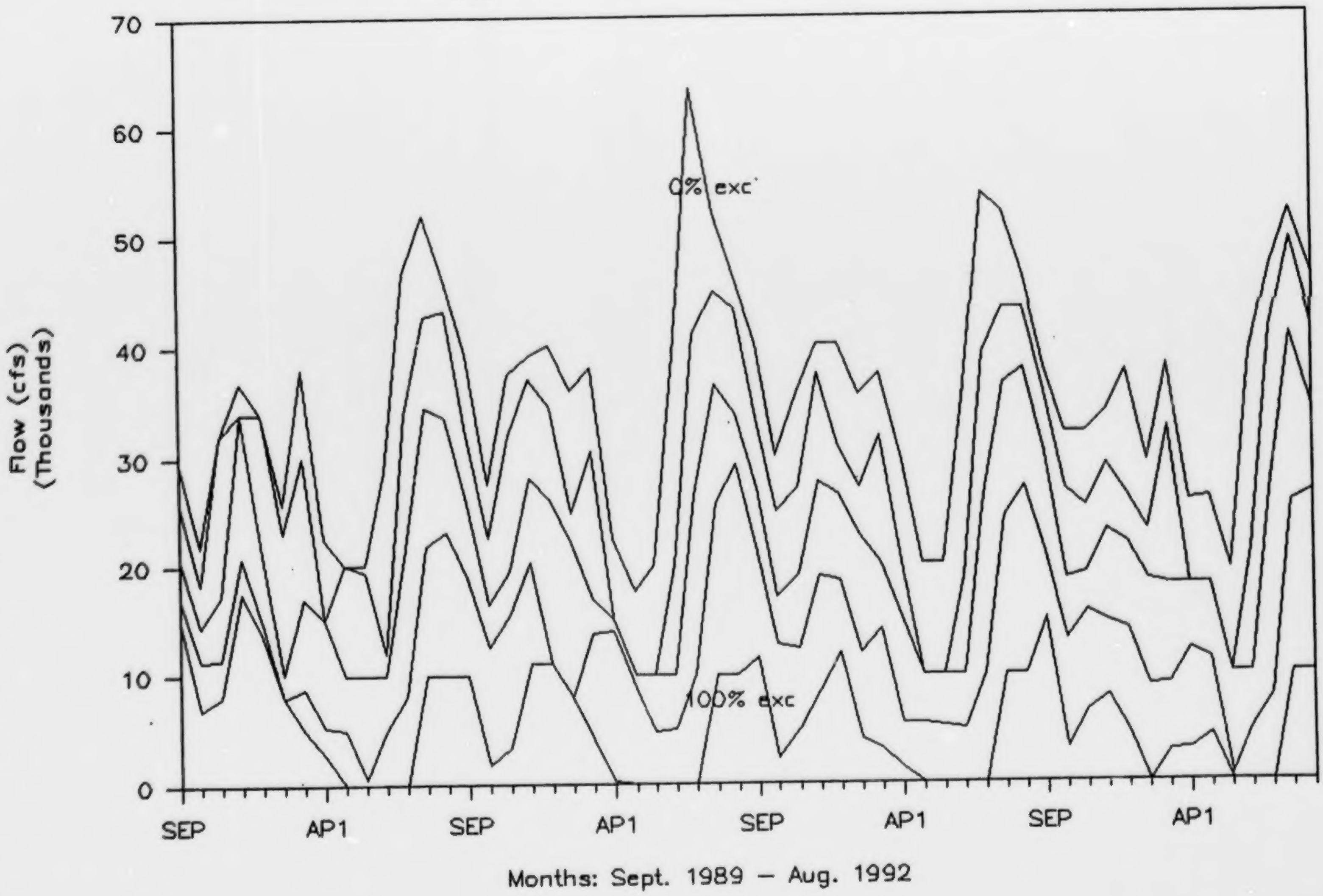


Figure A8.1.7 Flows at Mica Reservoir, Base Case (ARO): September 1993 - August 1996

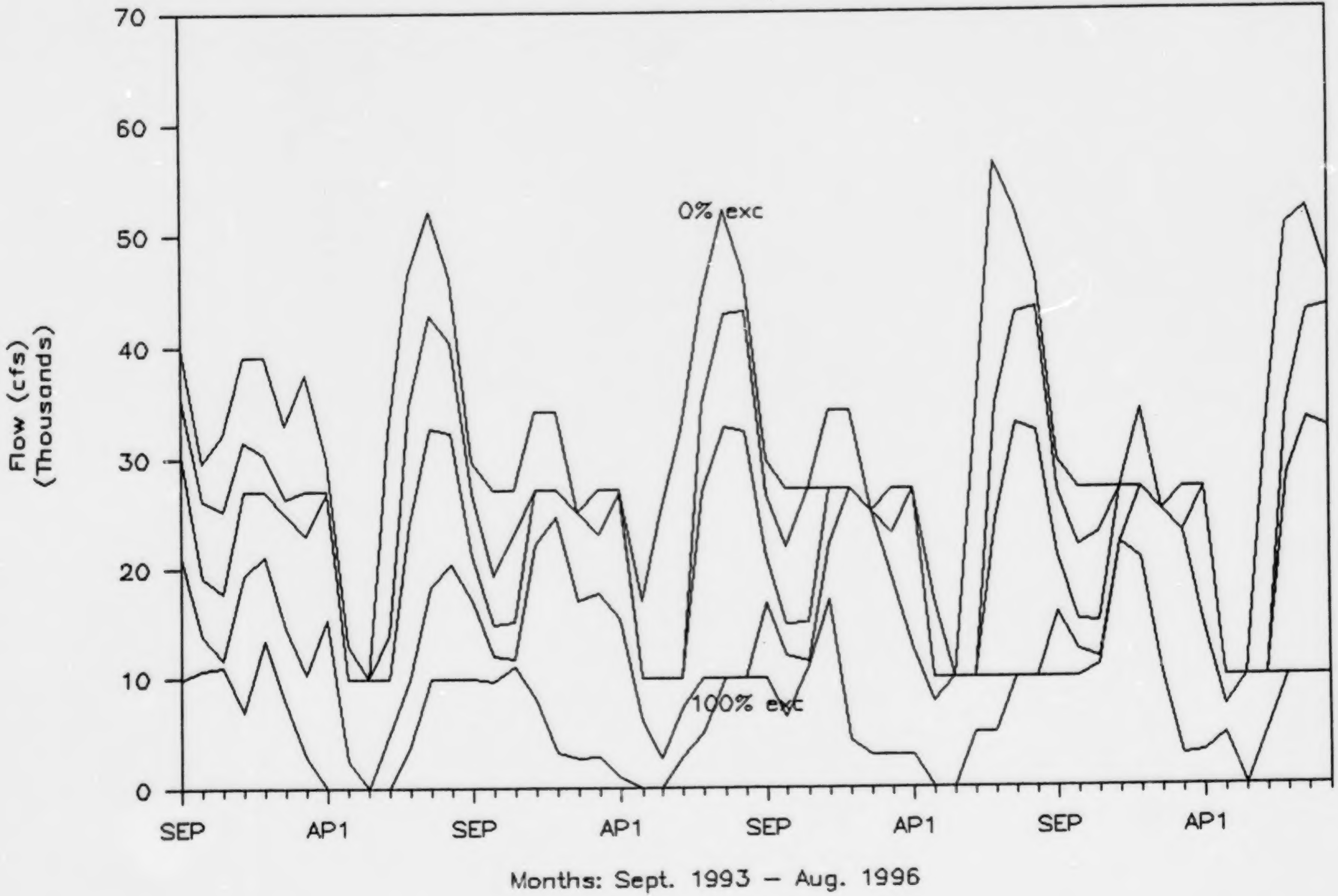


Figure A8.1.8 Flows at Mica Reservoir, Base Case (ARO): September 1997 - August 2000

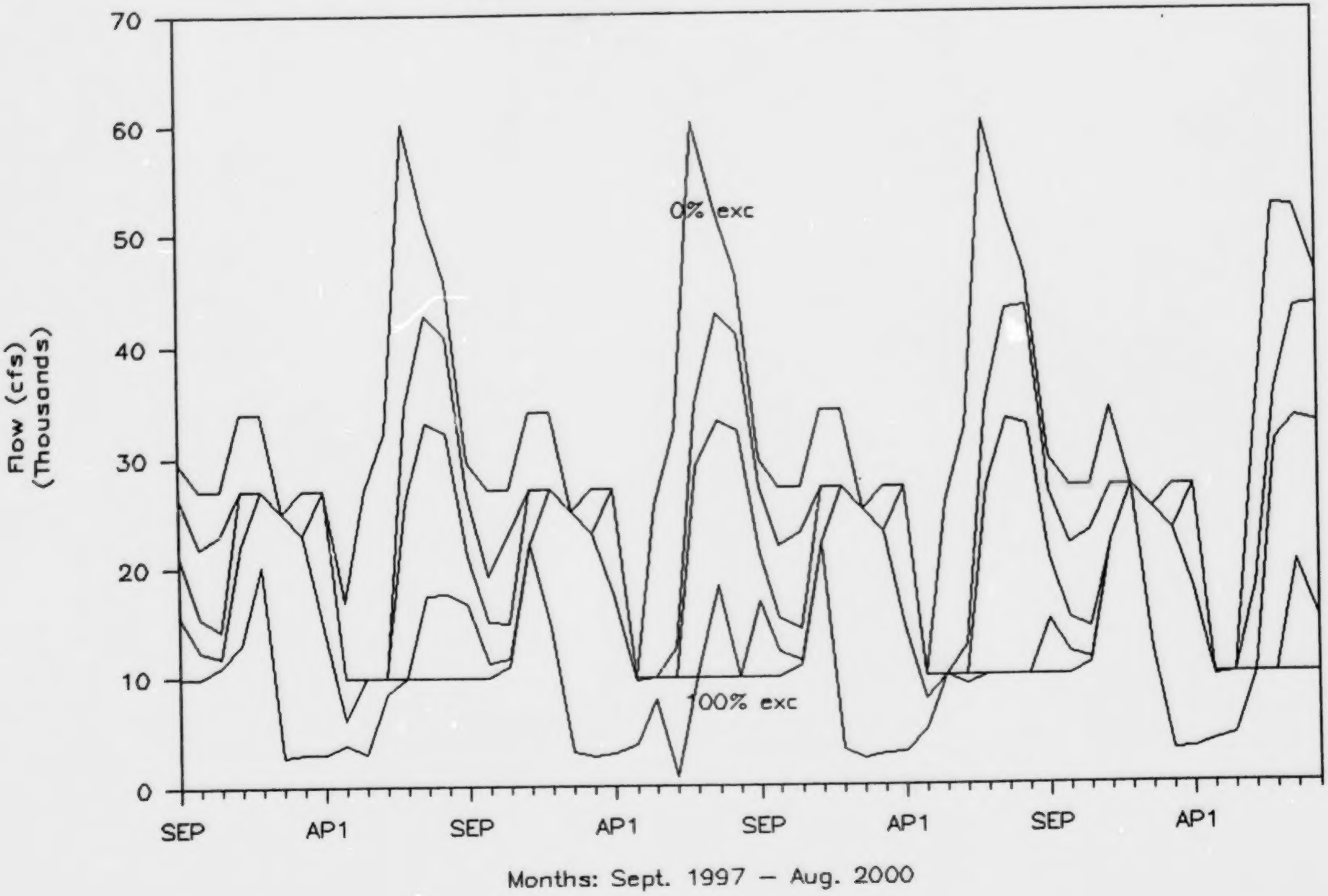


Figure A8.1.9 Flows at Mica Reservoir, Base Case (ARO): September 2001 - August 2004

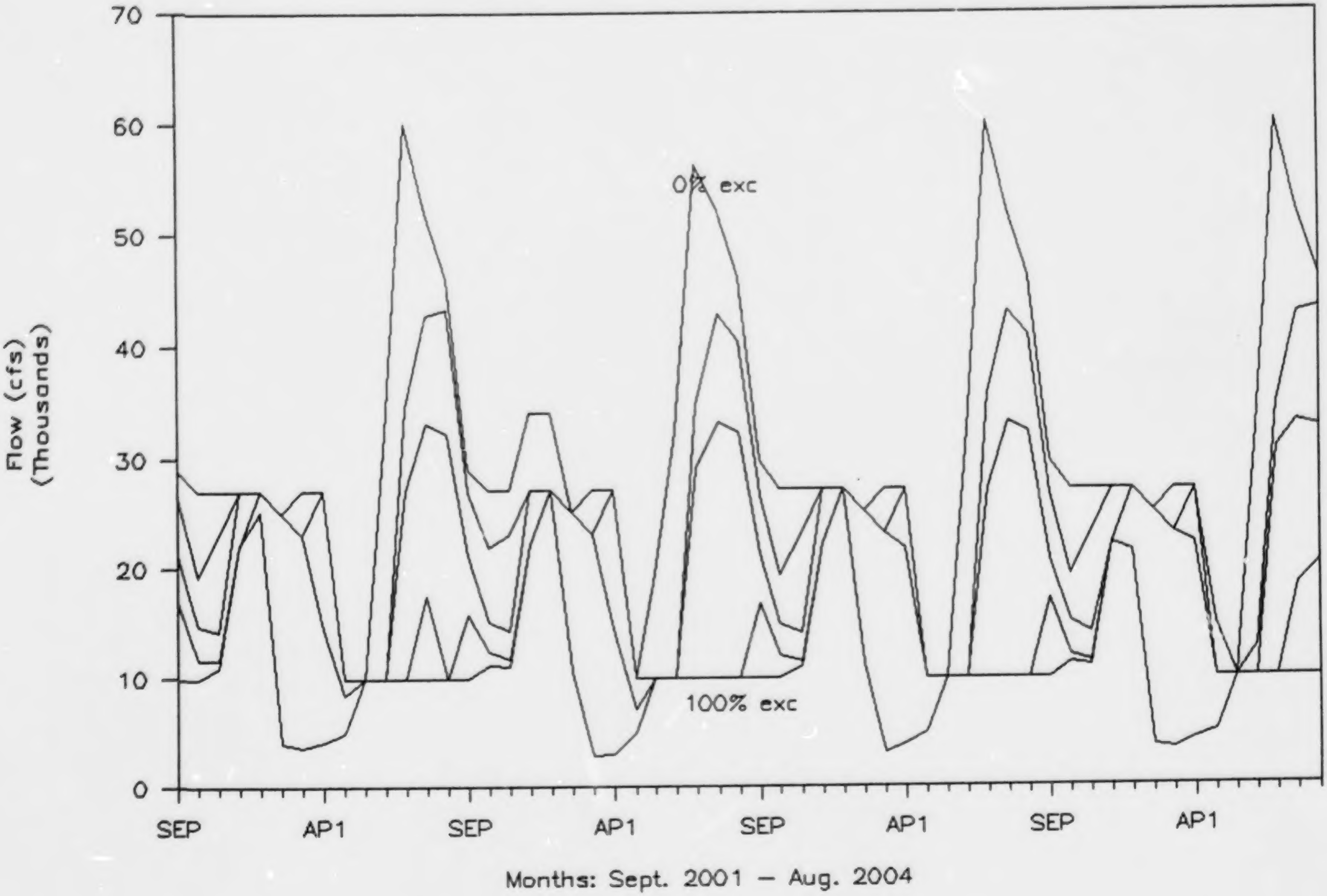


Figure A8.1.10 Flows at Mica Reservoir, Base Case (ARO): September 2005 - August 2008

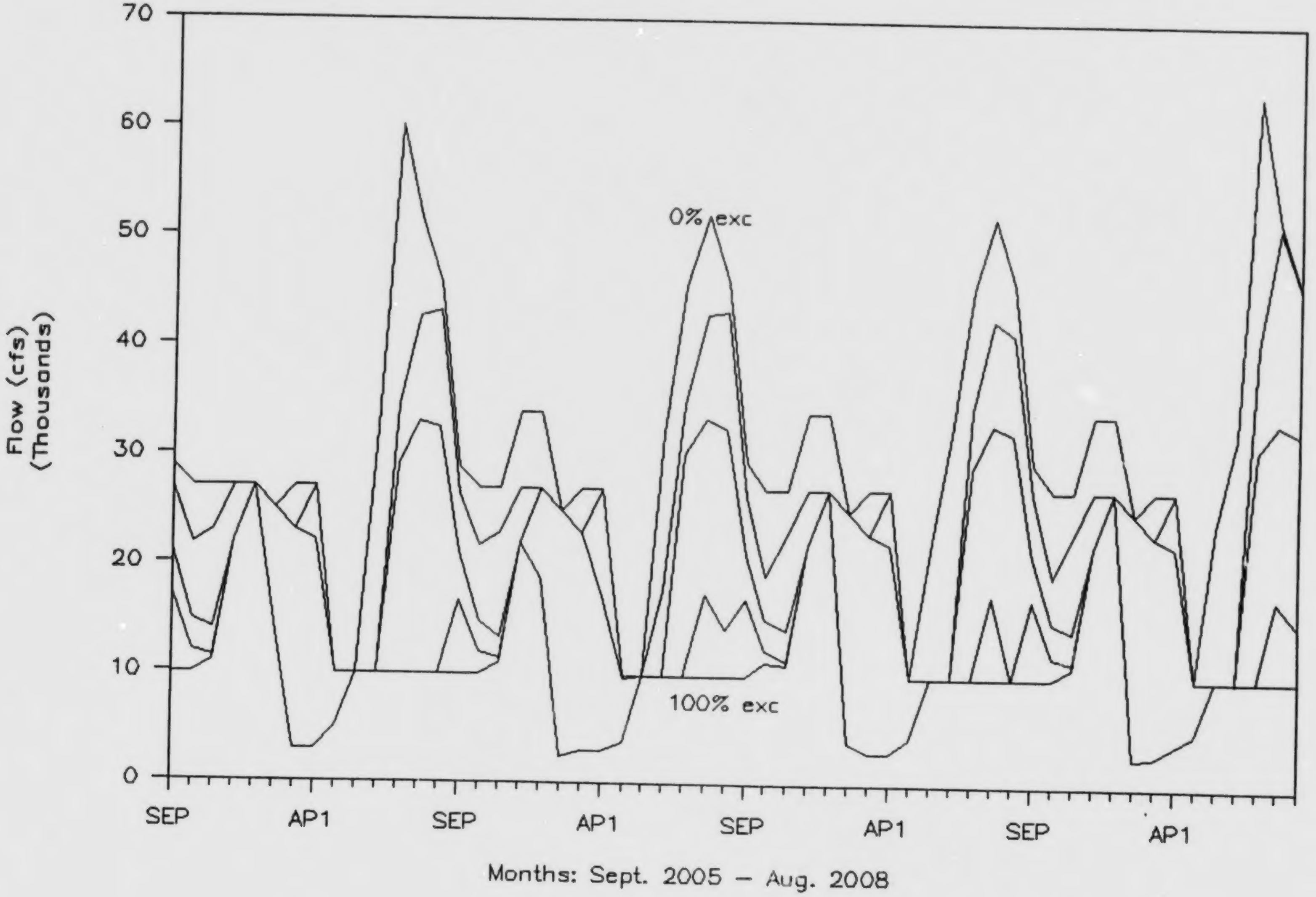


Figure A8.1.11 Elevations at Arrow Lakes Reservoir, Base Case (ARO): September 1989 . - August 1992

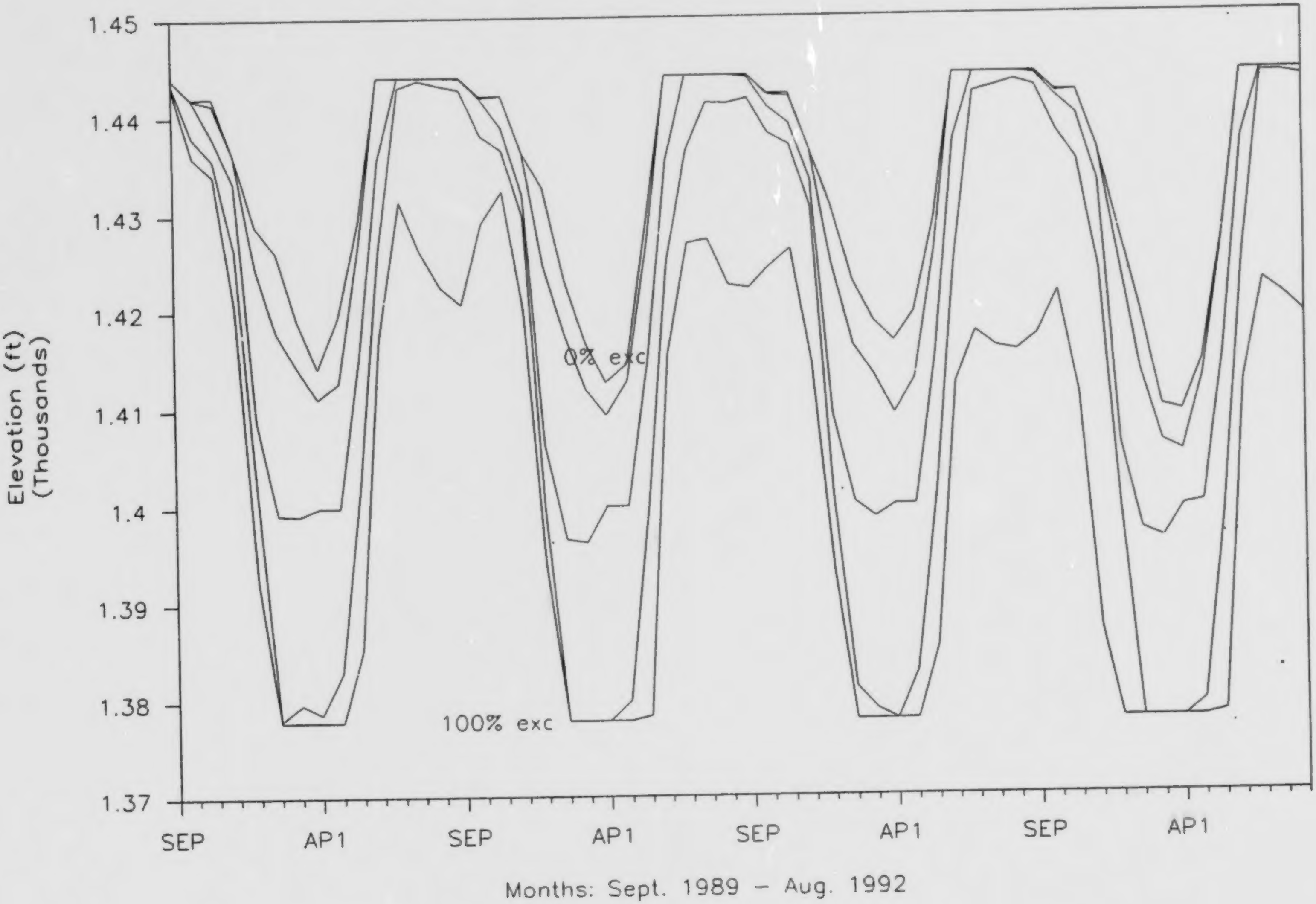


Figure A8.1.12 Elevations at Arrow Lakes Reservoir, Base Case (ARO): September 1993 - August 1996

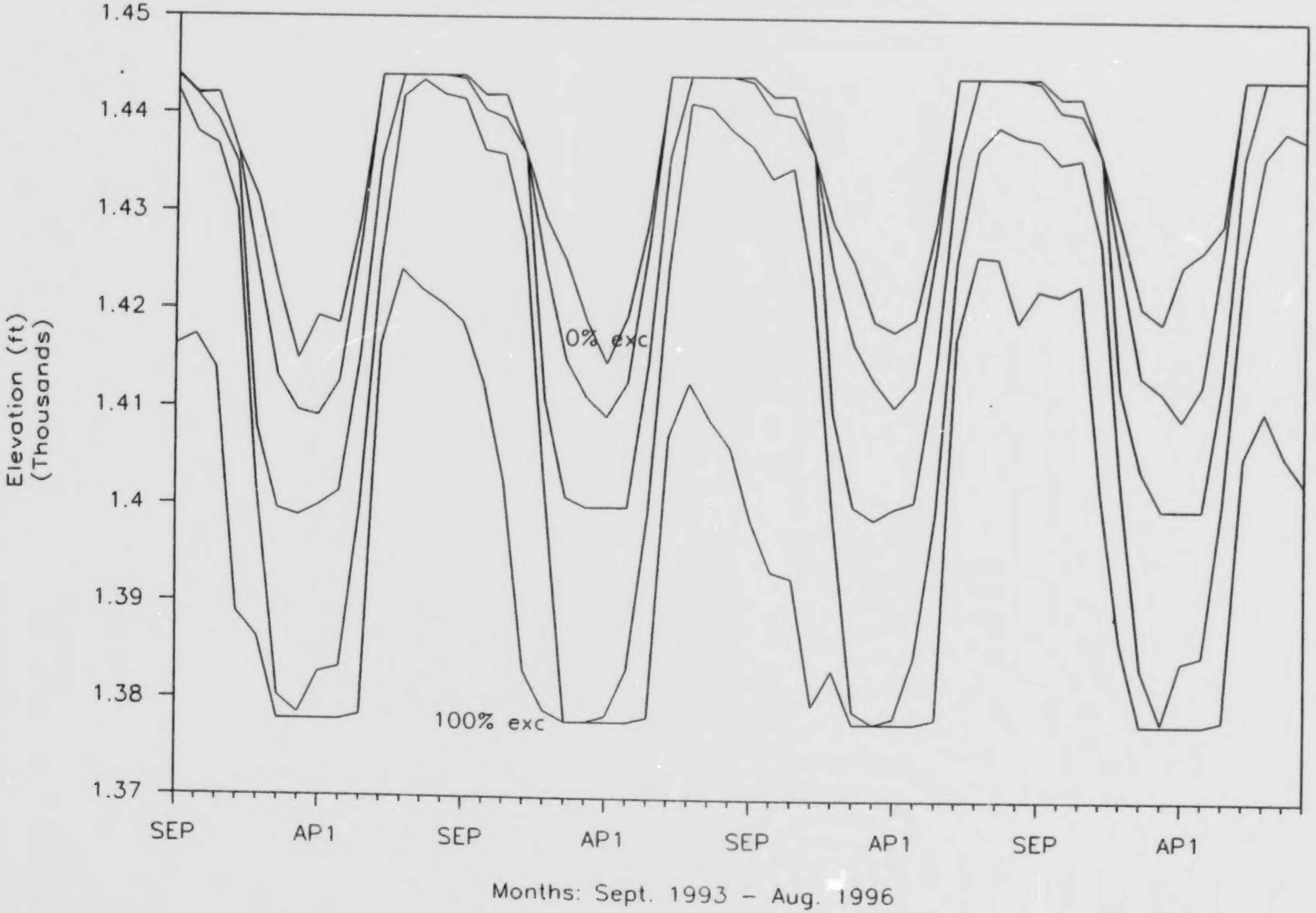


Figure A8.1.13 Elevations at Arrow Lakes Reservoir, Base Case (ARO): September 1997 - August 2000

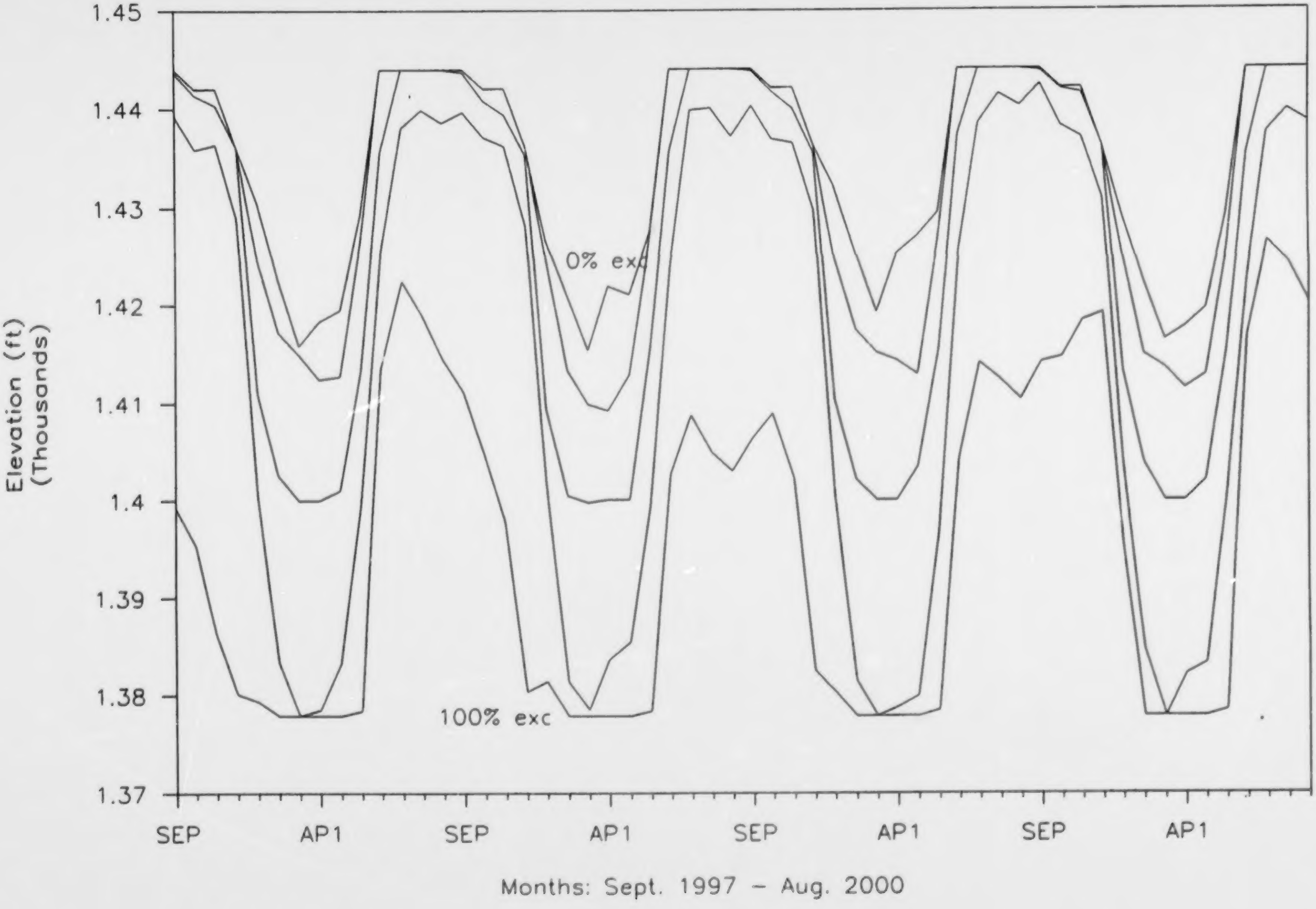


Figure A8.1.14 Elevations at Arrow Lakes Reservoir, Base Case (ARO): September 2001 - August 2004

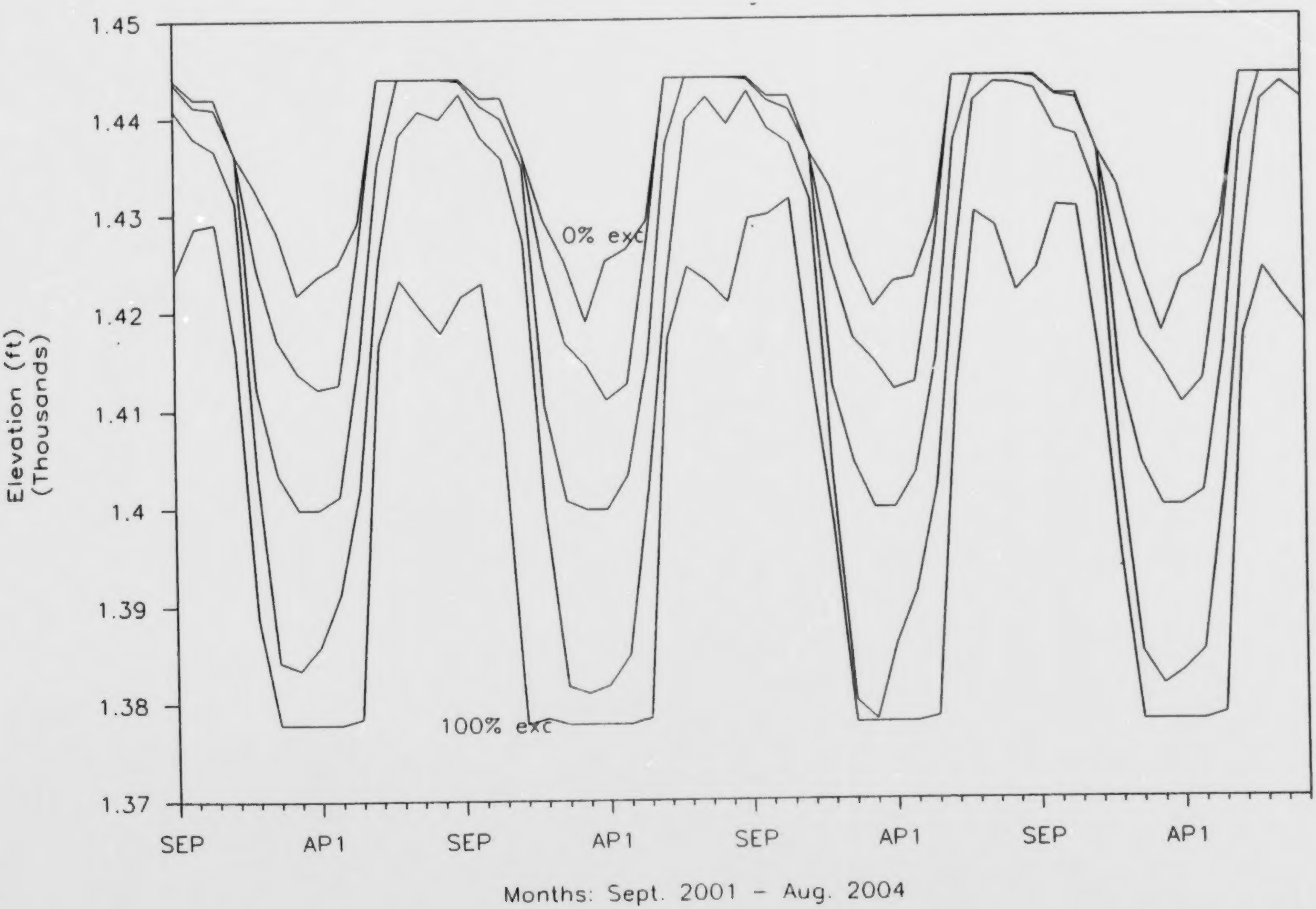


Figure A8.1.15 Elevations at Arrow Lakes Reservoir, Base Case (ARO): September 2005 - August 2008

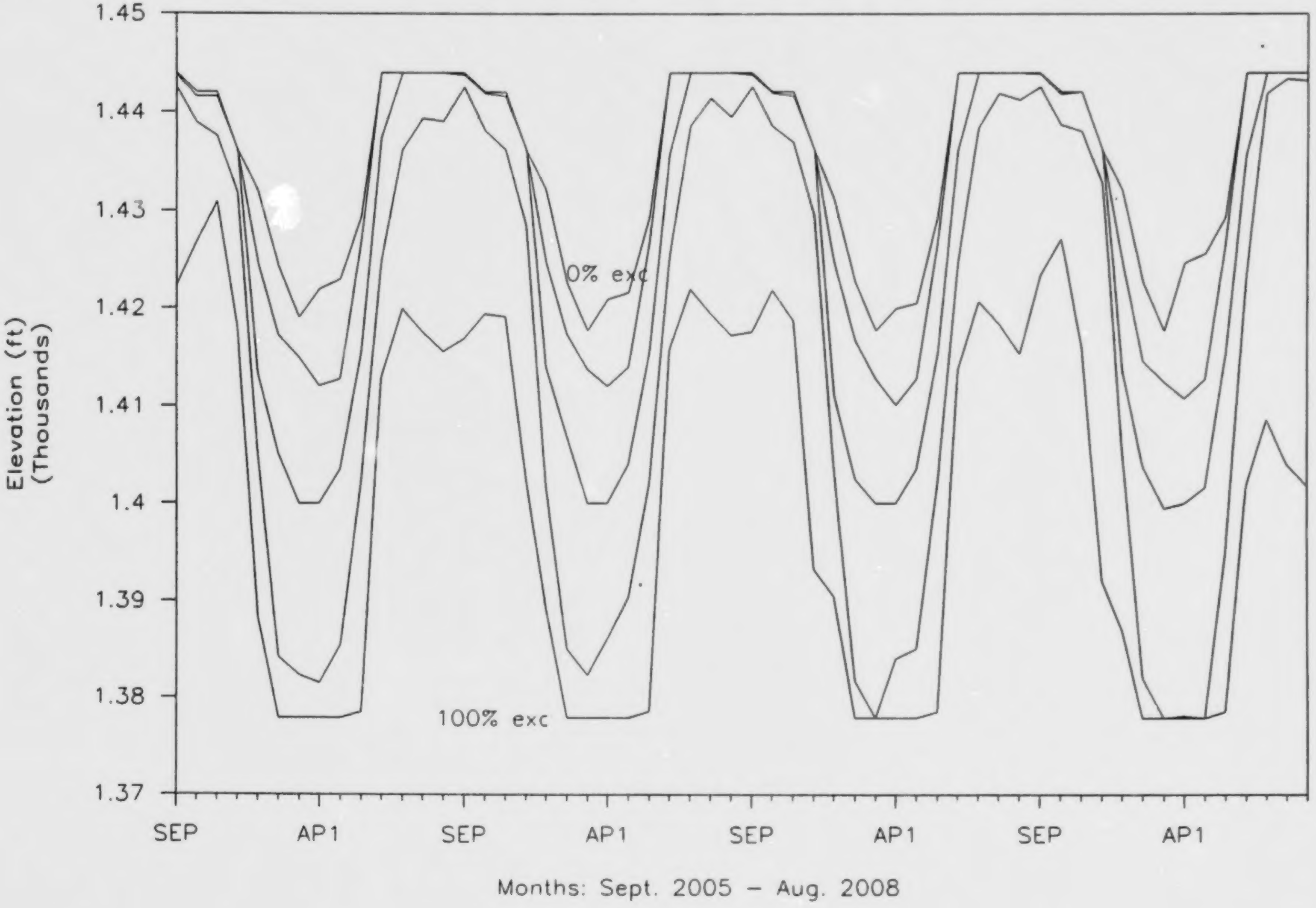


Figure A8.1.16 Flows at Arrow Lakes Reservoir, Base Case (ARO): September 1989 - August 1992

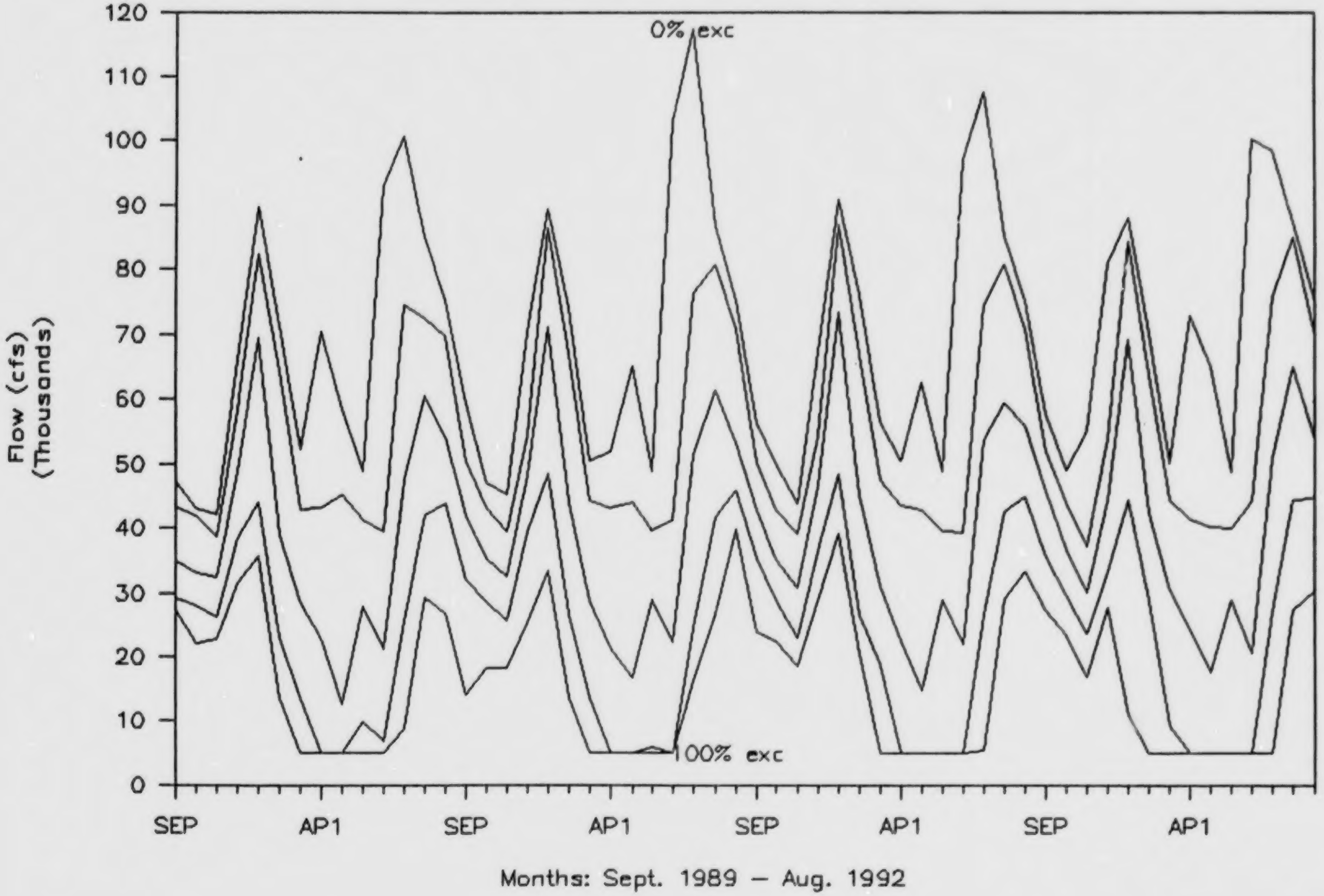


Figure A8.1.17 Flows at Arrow Lakes Reservoir, Base Case (ARO): September 1993 - August 1996

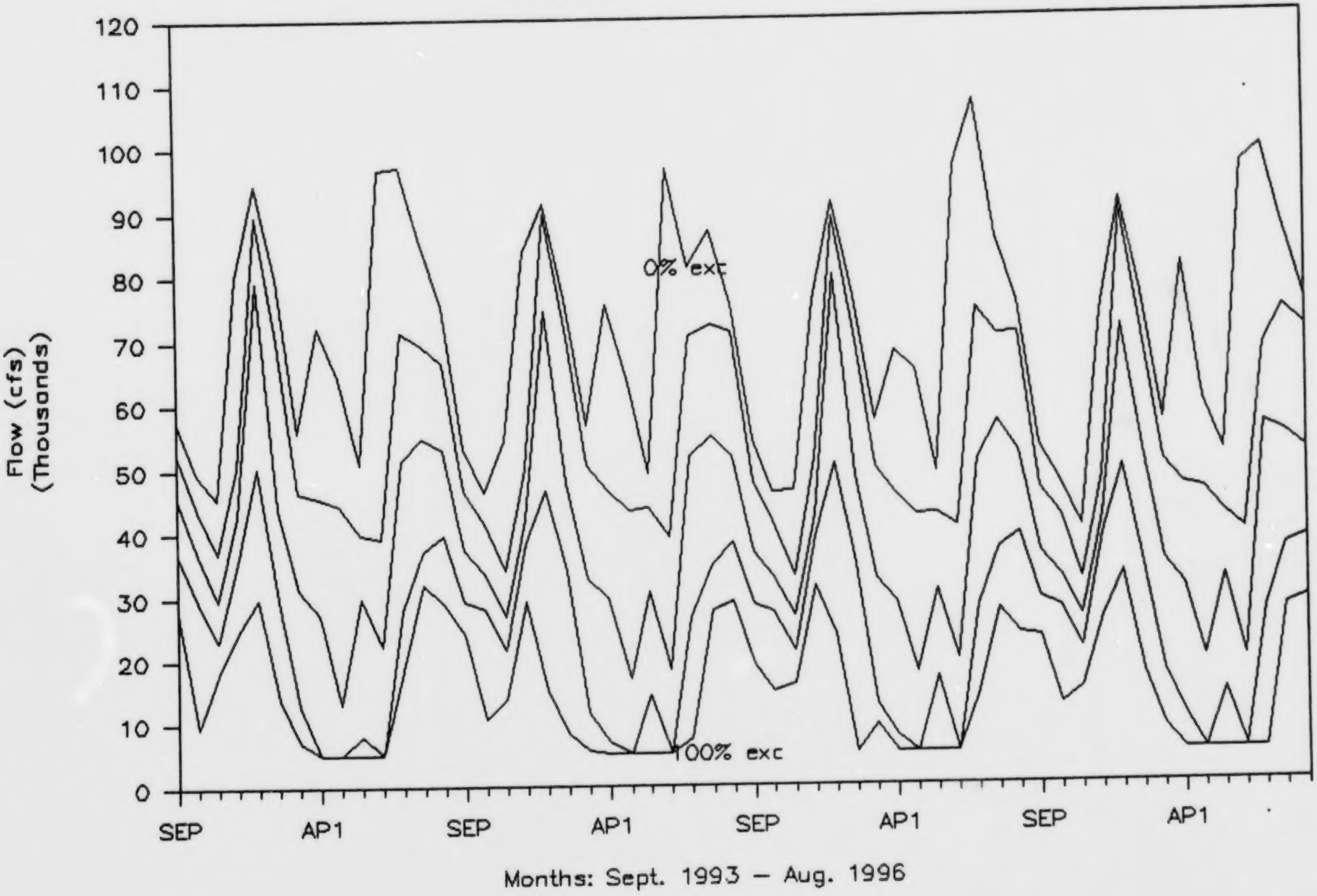


Figure A8.1.18 Flows at Arrow Lakes Reservoir, Base Case (ARO): September 1997 - August 2000

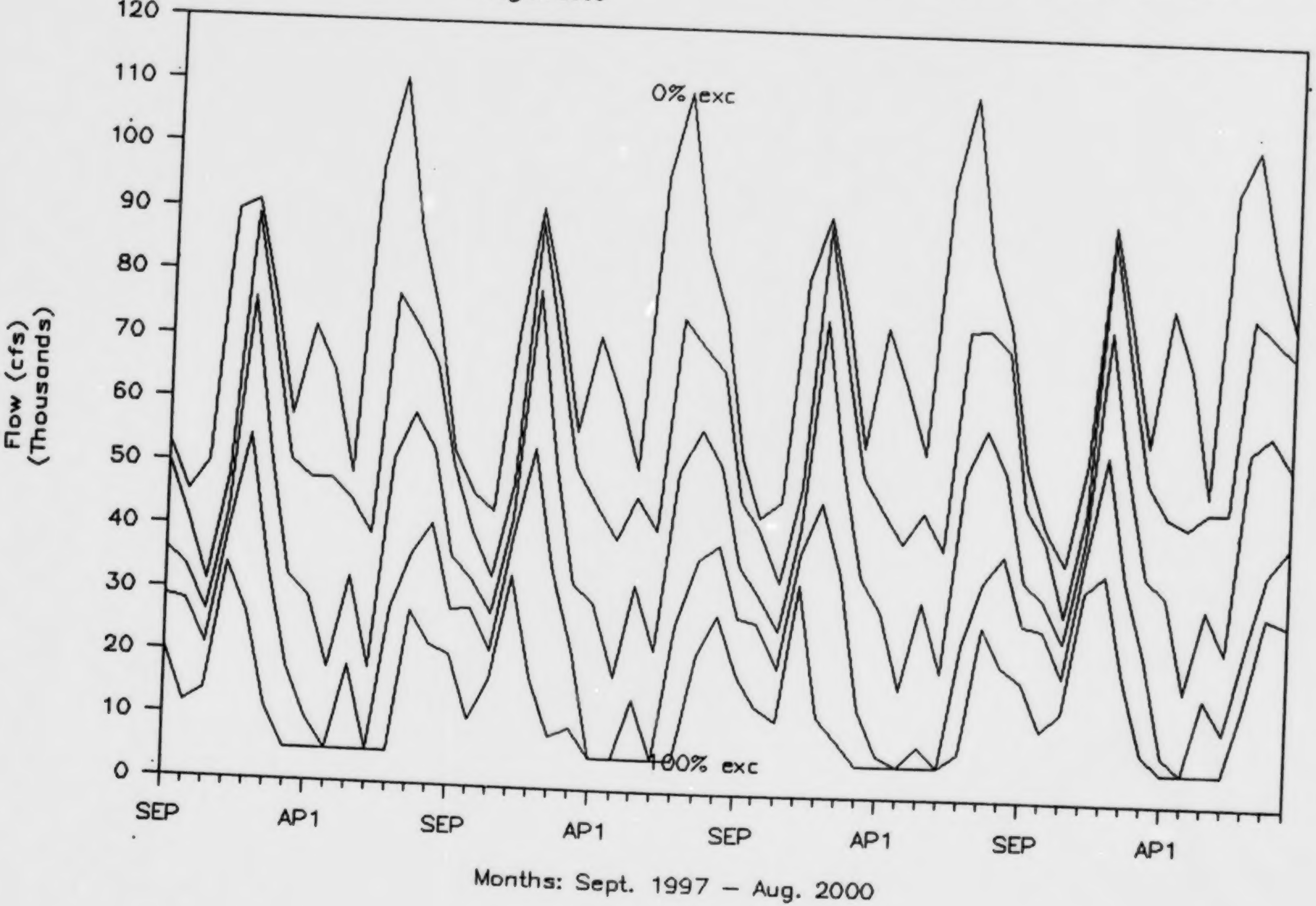


Figure A8.1.19 Flows at Arrow Lakes Reservoir, Base Case (ARO): September 2001 - August 2004

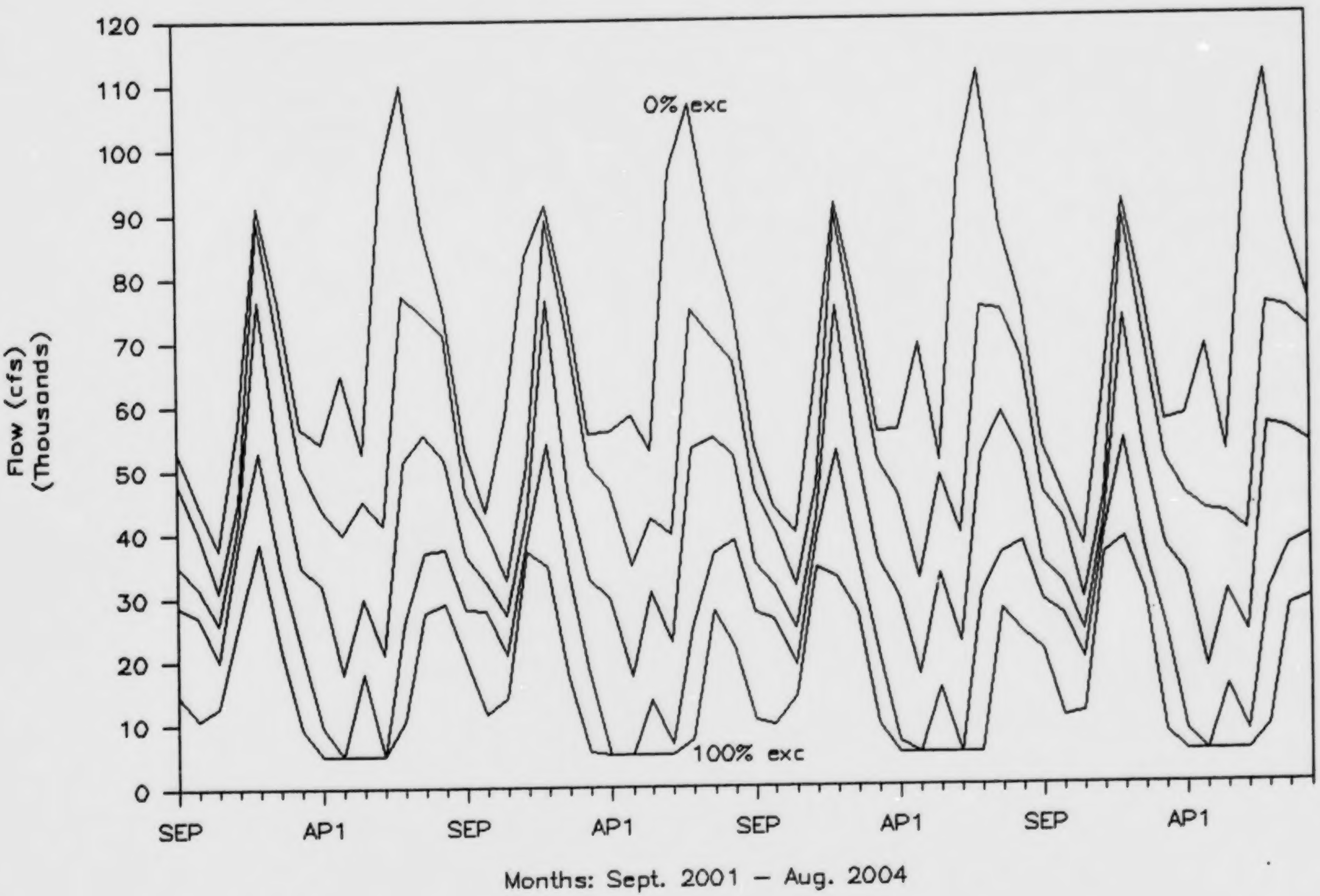
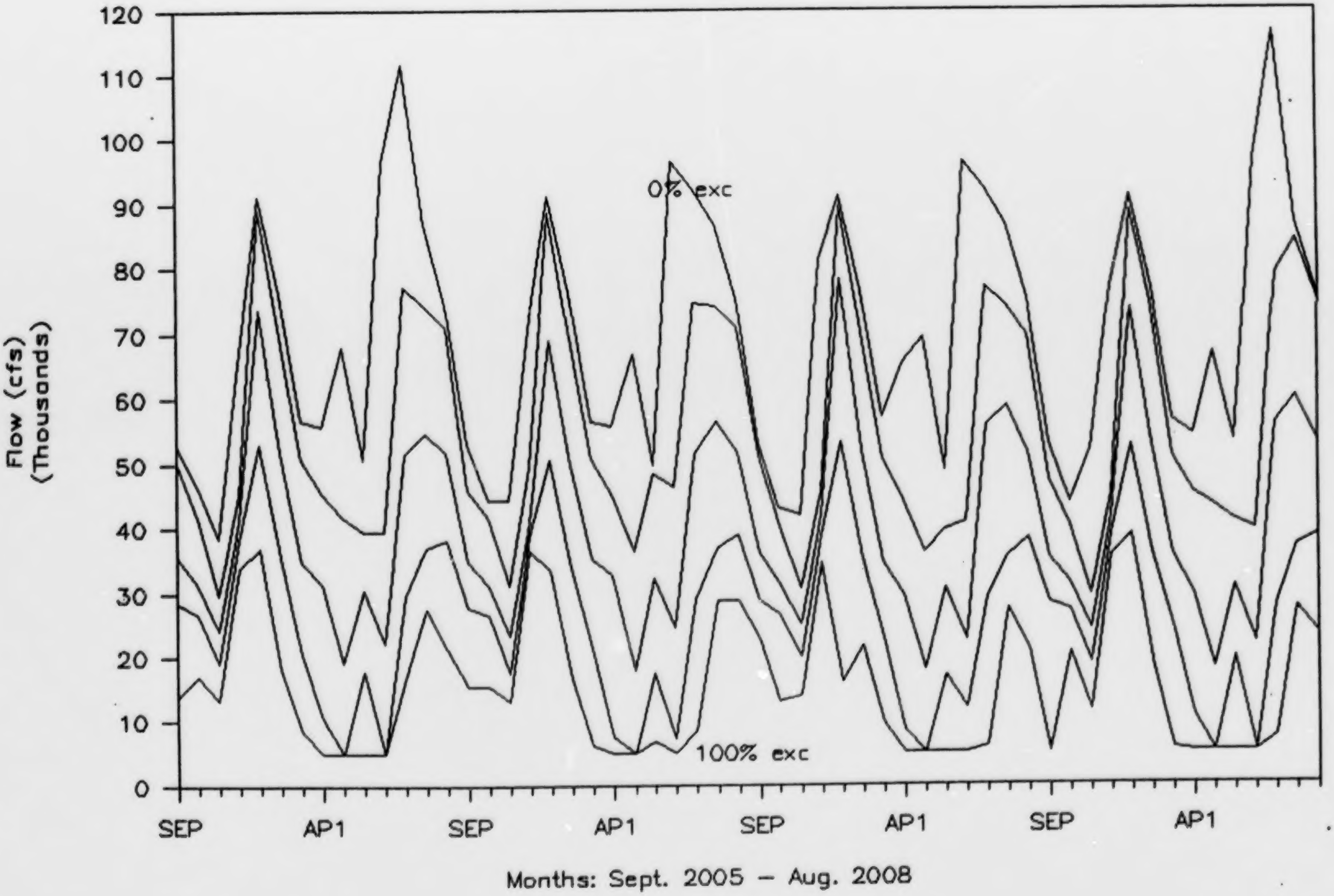


Figure A8.1.20 Flows at Arrow Lakes Reservoir, Base Case (ARO): September 2005 - August 2008



APPENDIX 8.2

Regime 1 (ARO)

Figure A8.2.1 Elevations at Mica Reservoir, Regime 1 (ARO): September 1989 - August 1992

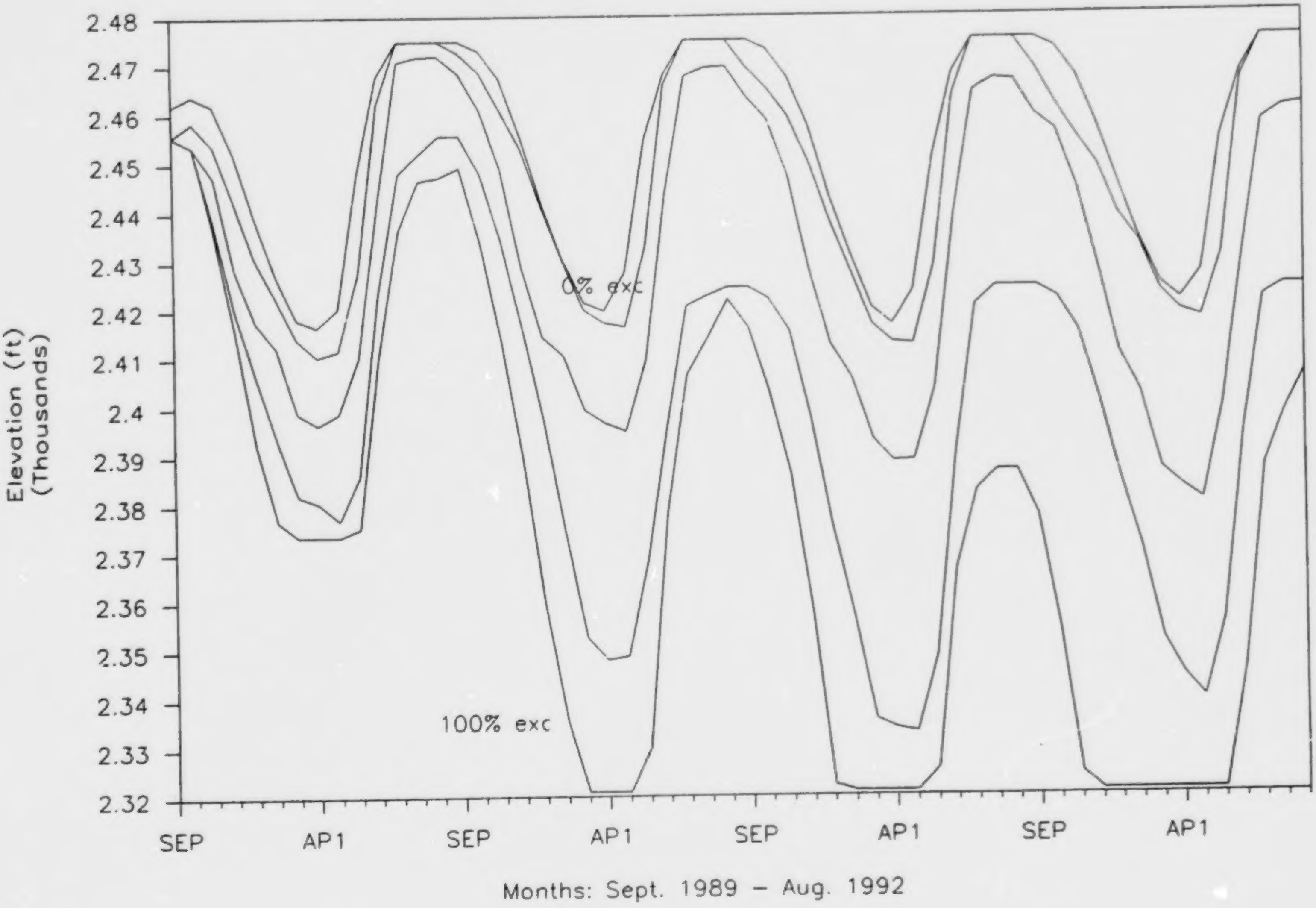


Figure A8.2.2 Elevations at Mica Reservoir, Regime 1 (ARO): September 1993 - August 1996

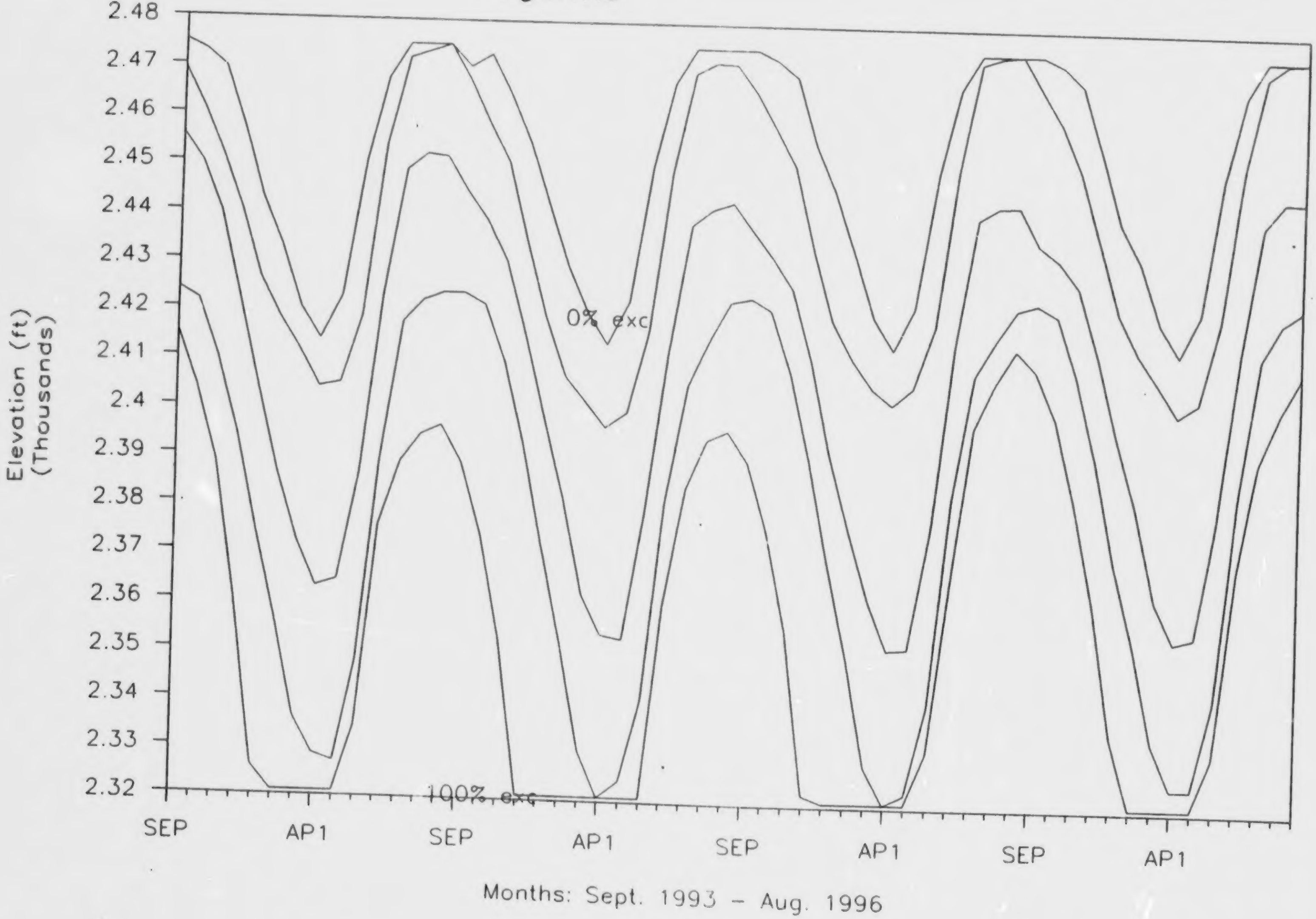
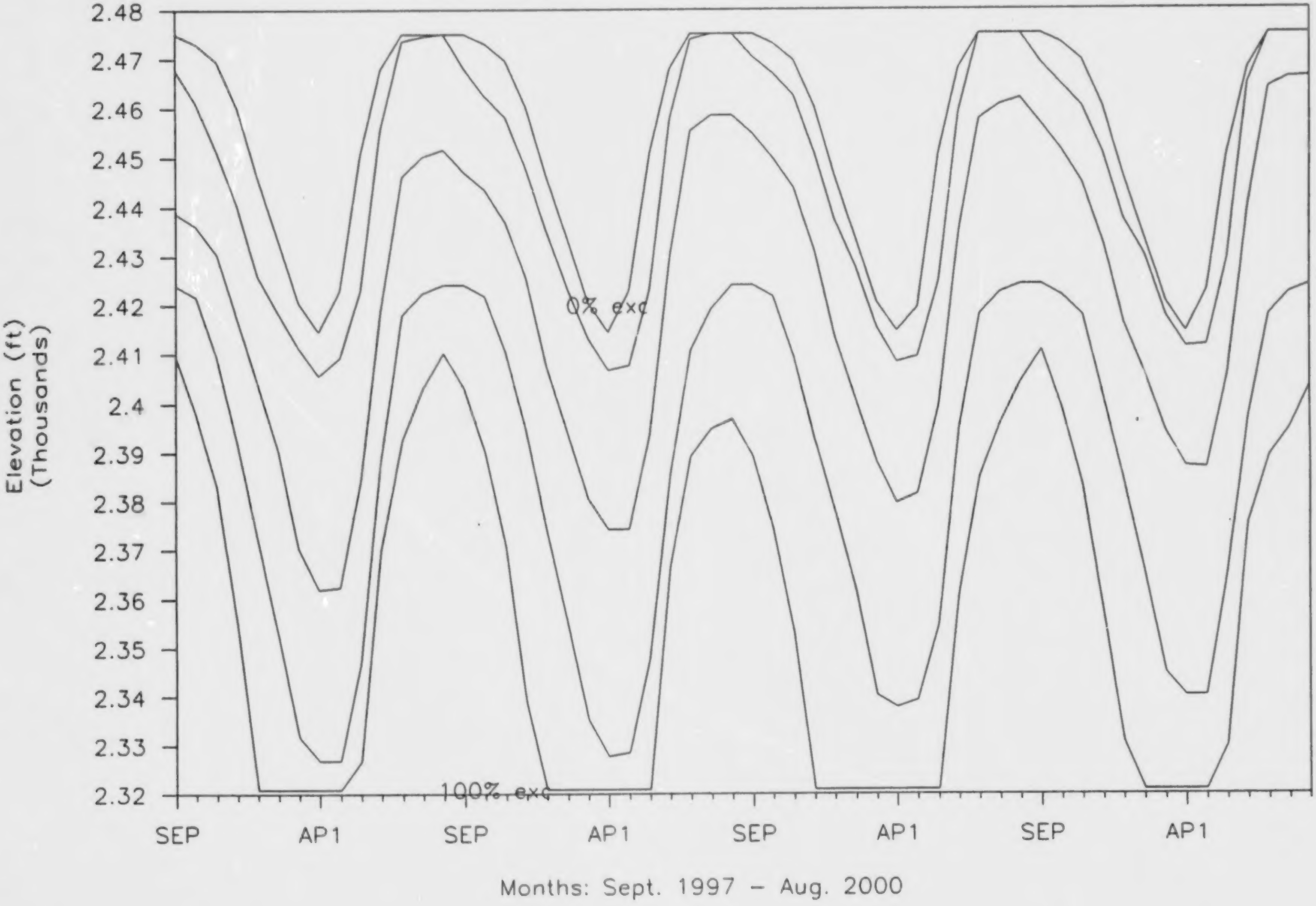


Figure A8.2.3 Elevations at Mica Reservoir, Regime 1 (ARO): September 1997 - August 2000



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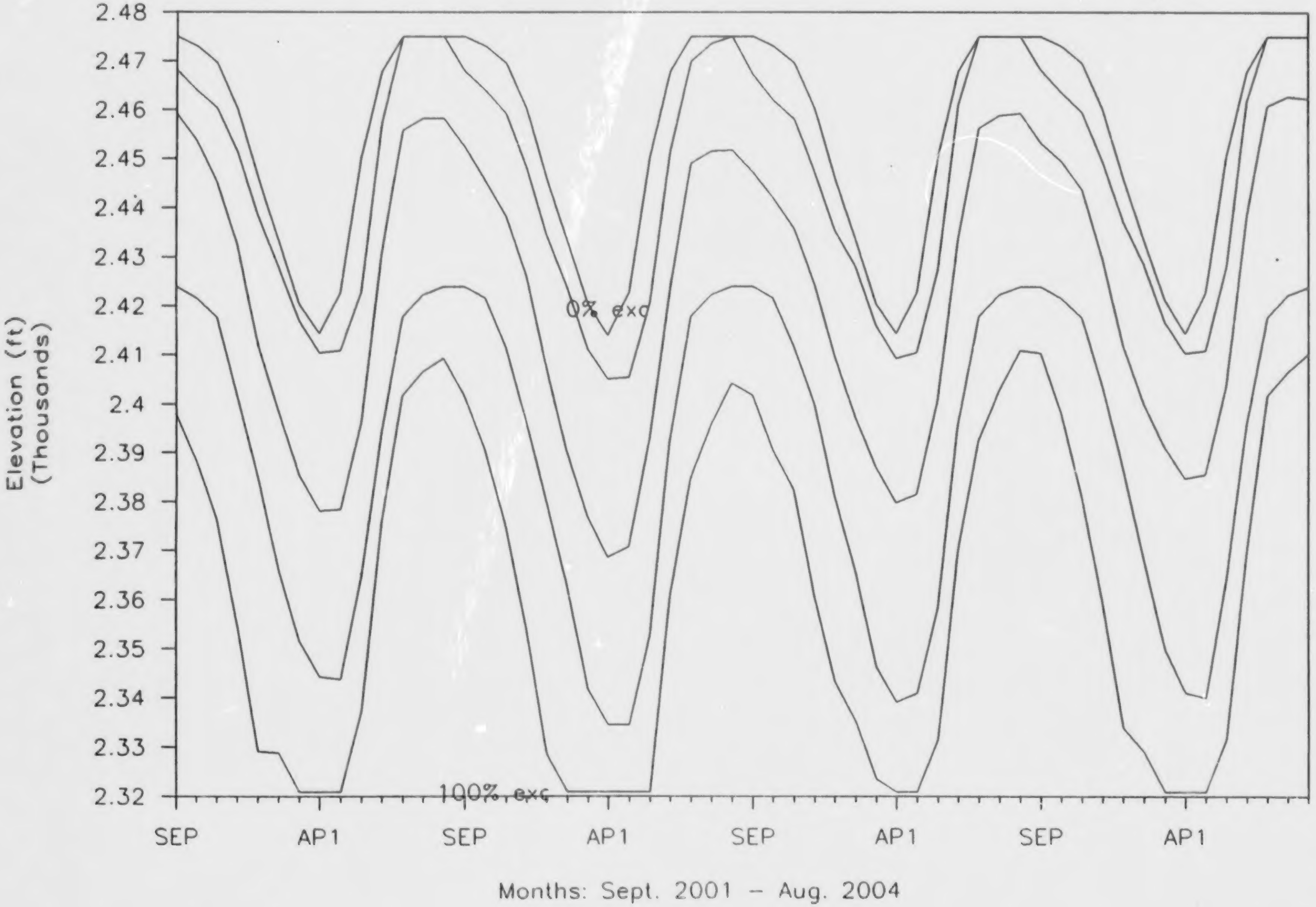


Figure A8.2.5 Elevations at Mica Reservoir, Regime 1 (ARO): September 2005 - August 2008

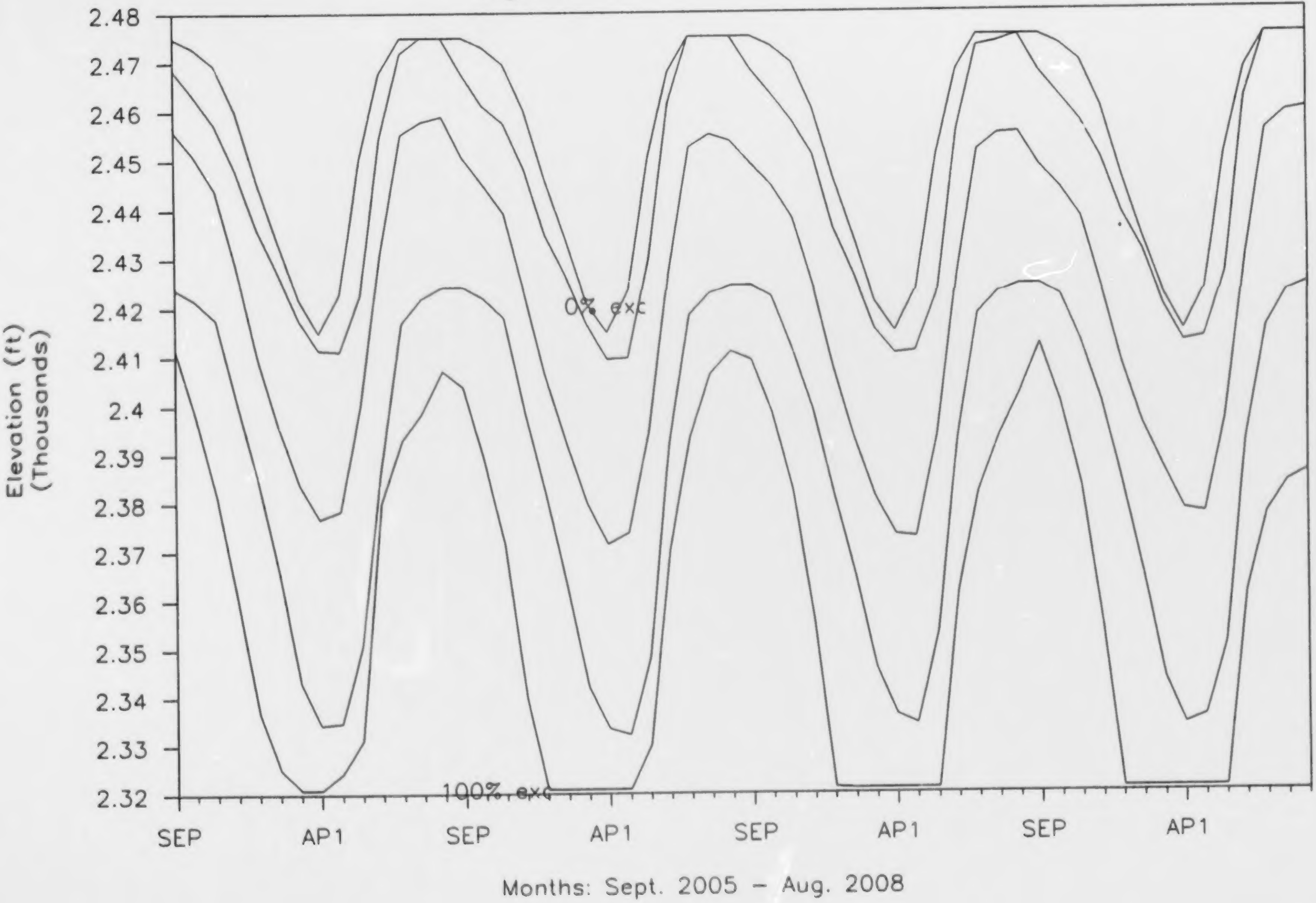


Figure A8.2.6 Flows at Mica Reservoir, Regime 1 (ARO): September 1989 - August 1992

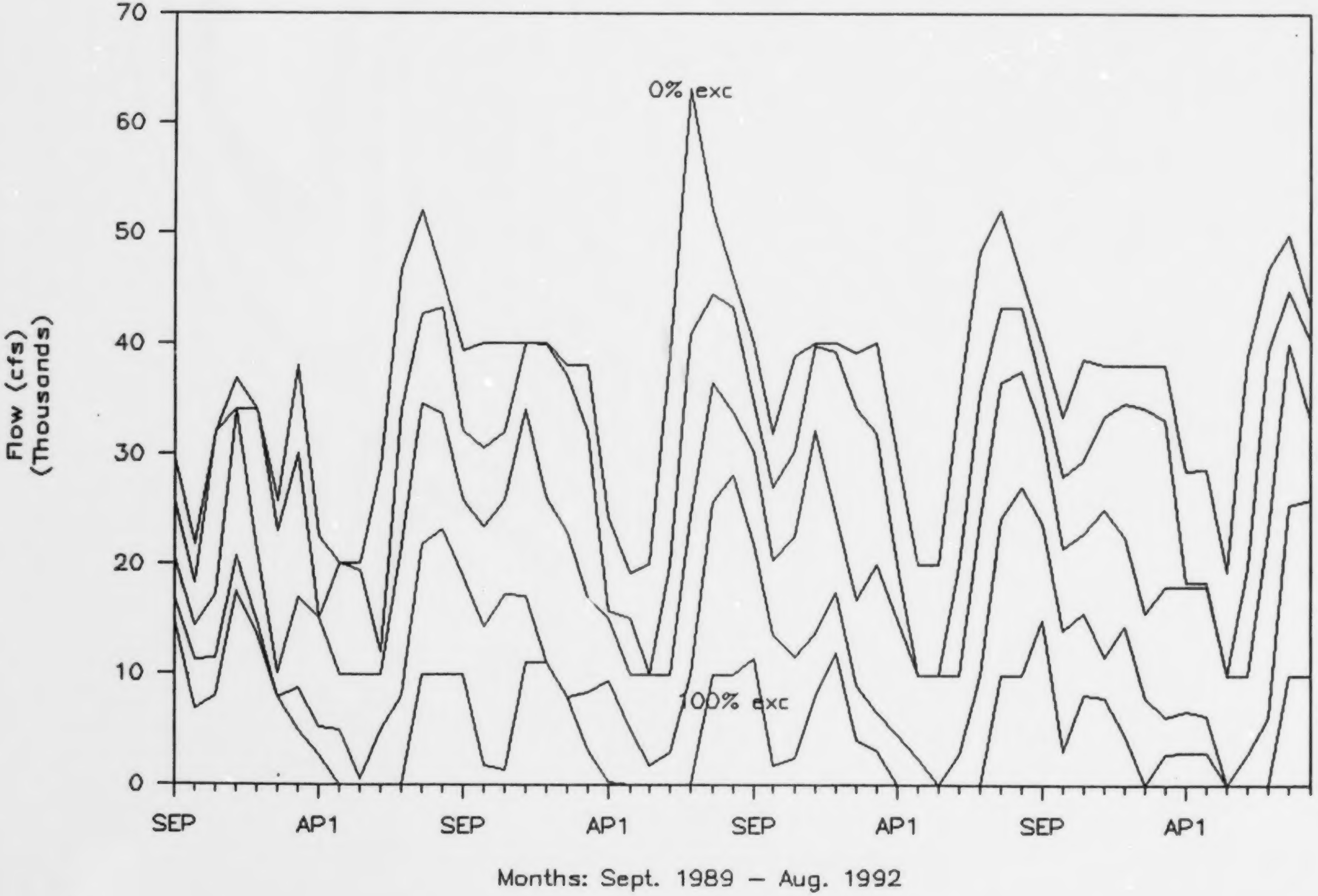


Figure A8.2.7 Flows at Mica Reservoir, Regime 1 (ARO): September 1993 - August 1996

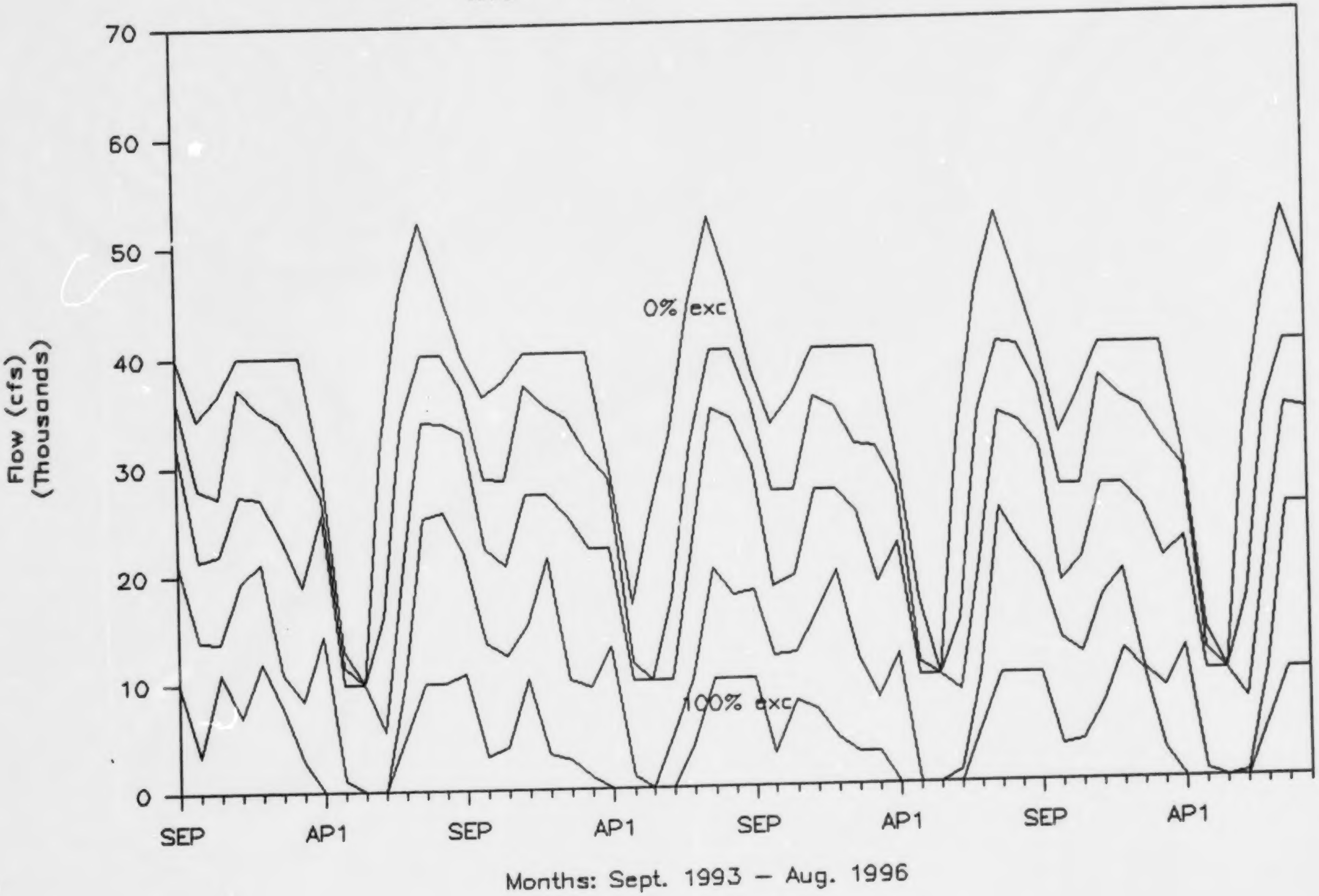


Figure A8.2.8 Flows at Mica Reservoir, Regime 1 (ARO): September 1997 - August 2000

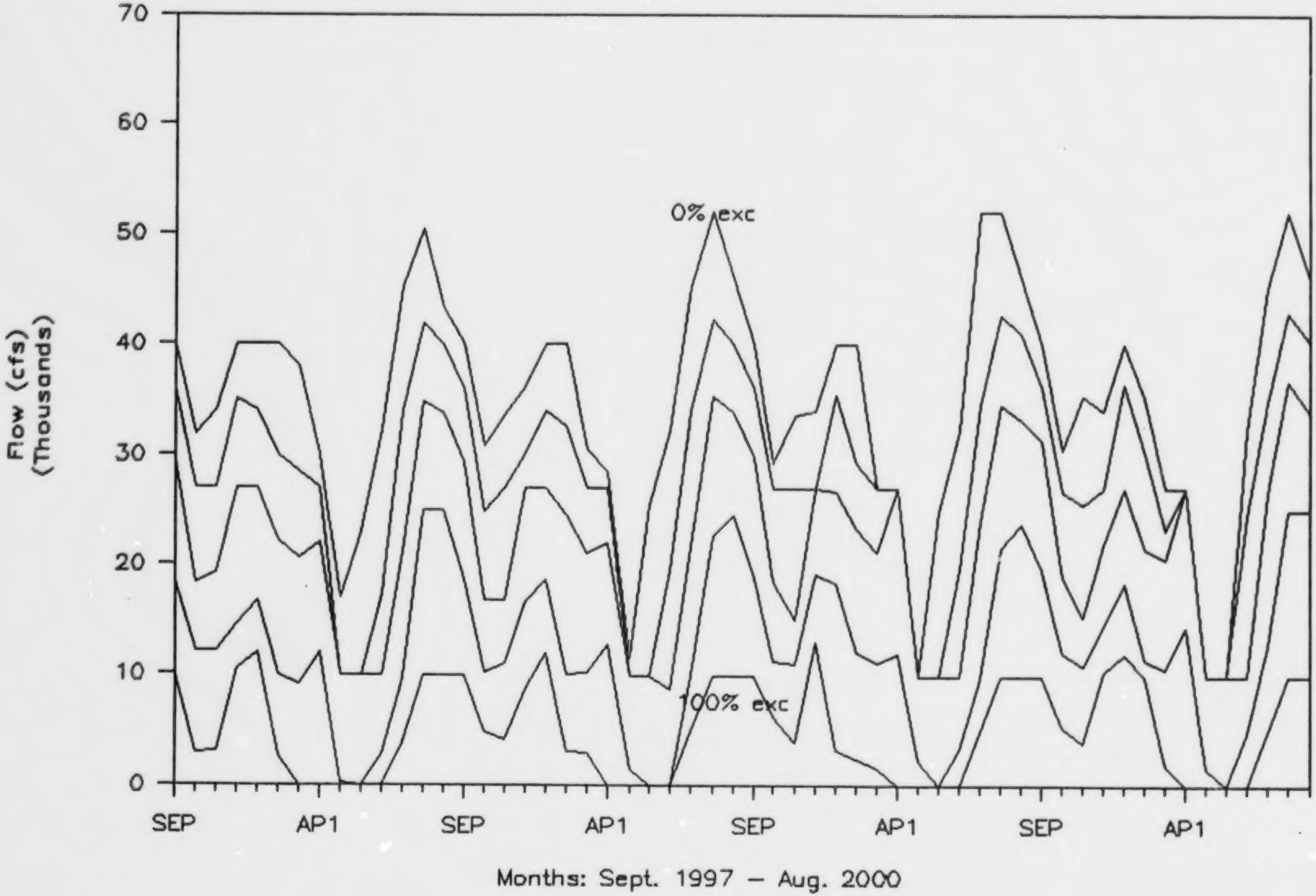


Figure A8.2.9 Flows at Mica Reservoir, Regime 1 (ARO): September 2001 - August 2004

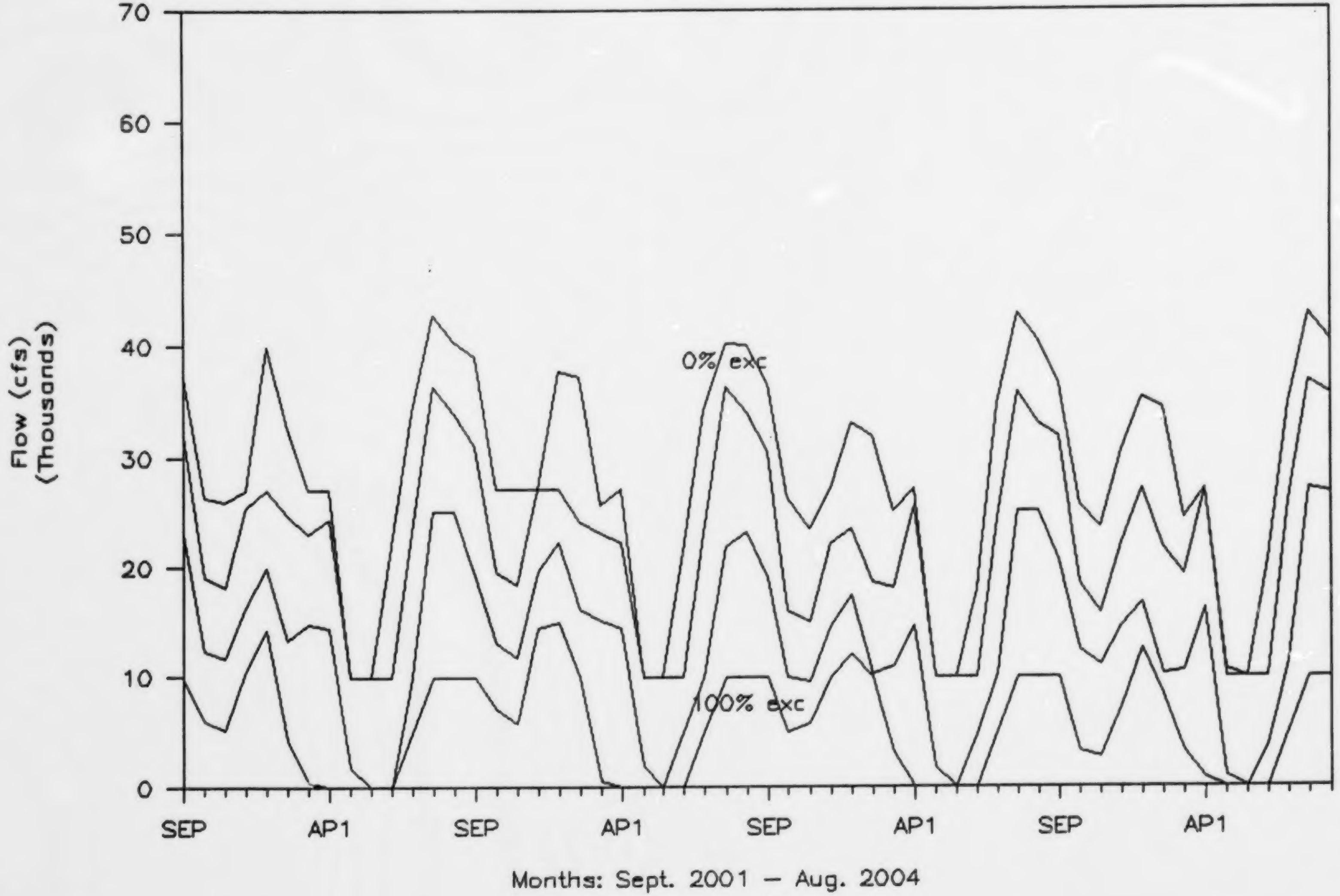


Figure A8.2.10 Flows at Mica Reservoir, Regime 1 (ARO): September 2005 - August 2008

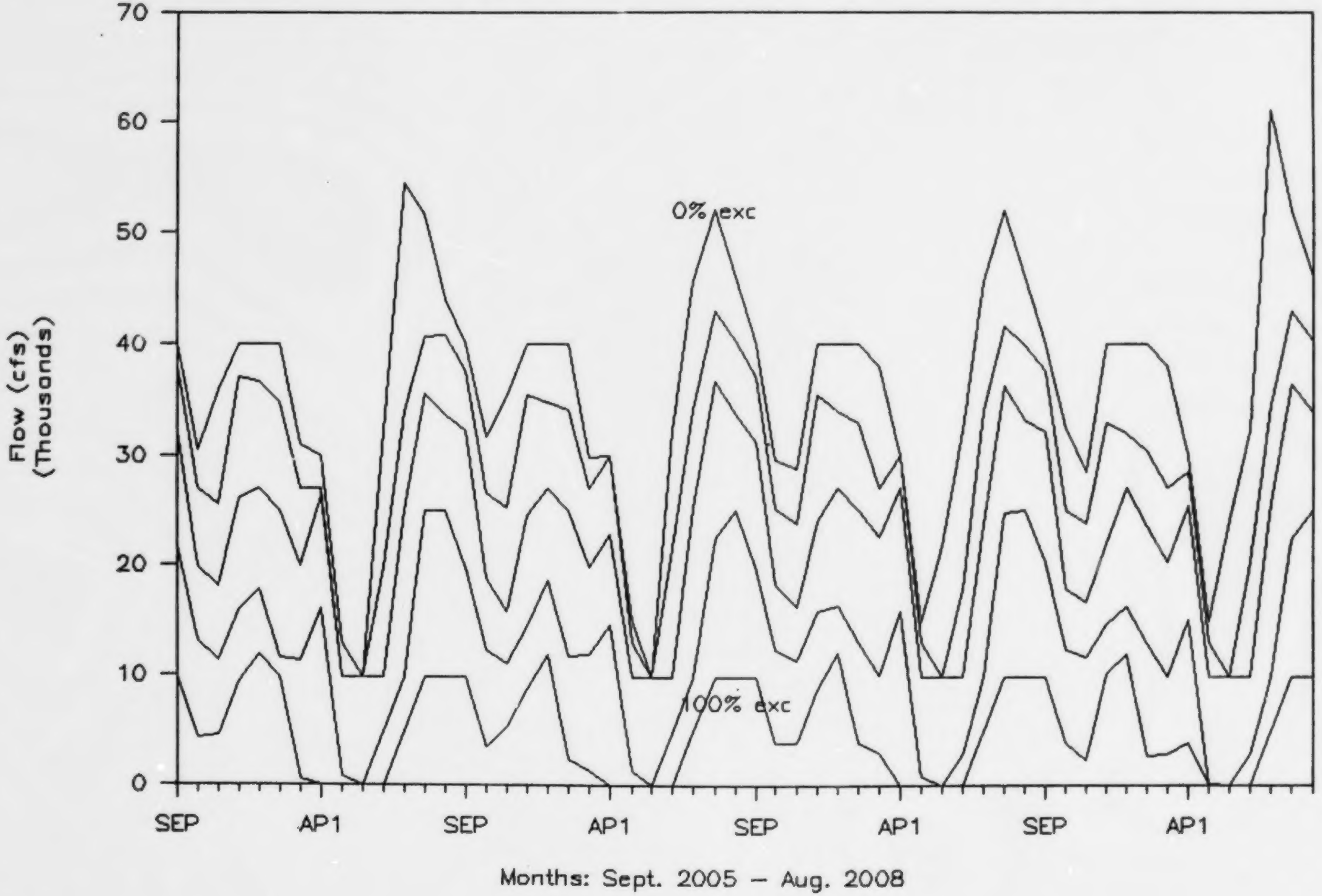
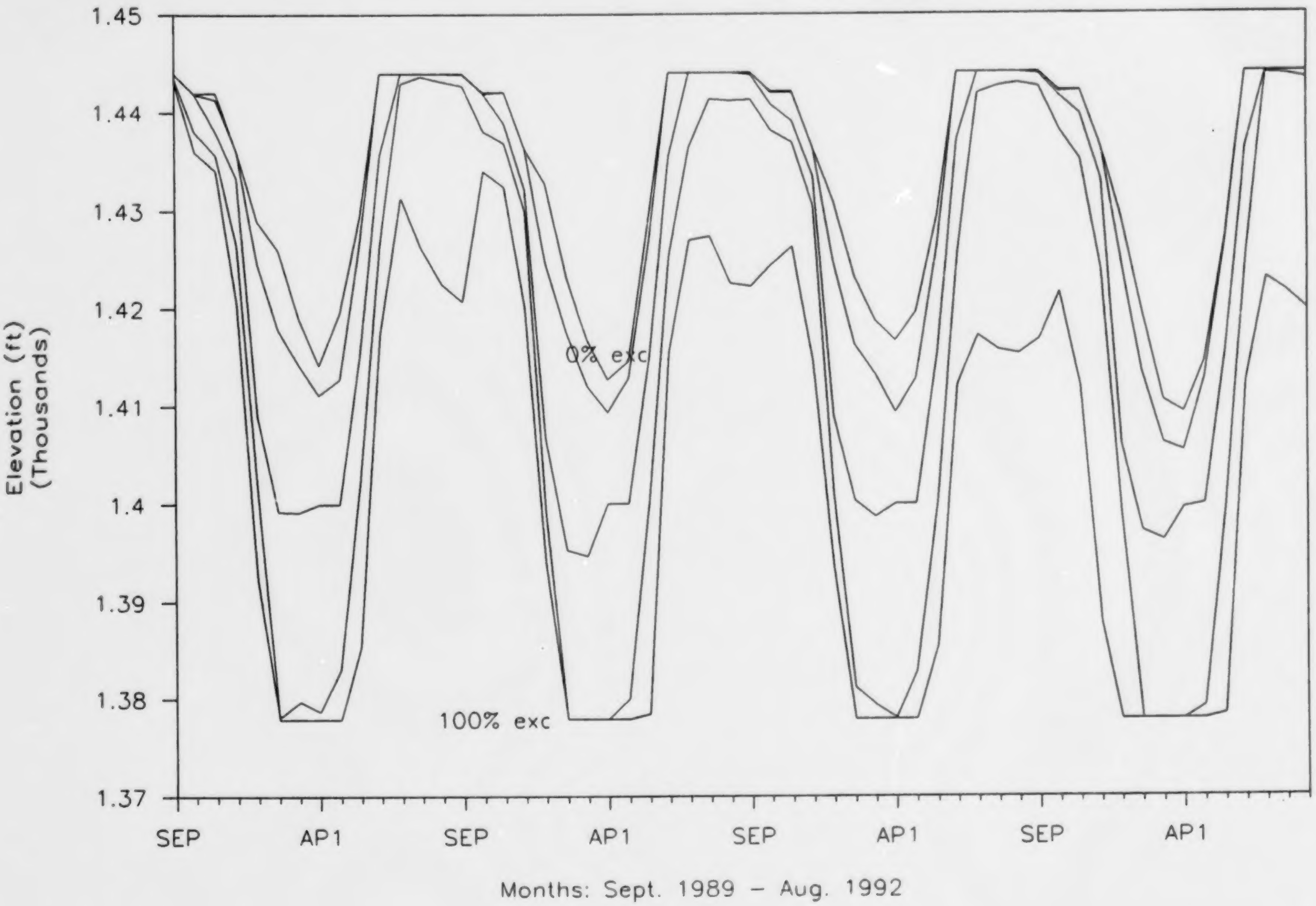


Figure A8.2.11 Elevations at Arrow Lakes Reservoir, Regime 1 (ARO): September 1989 - August 1992



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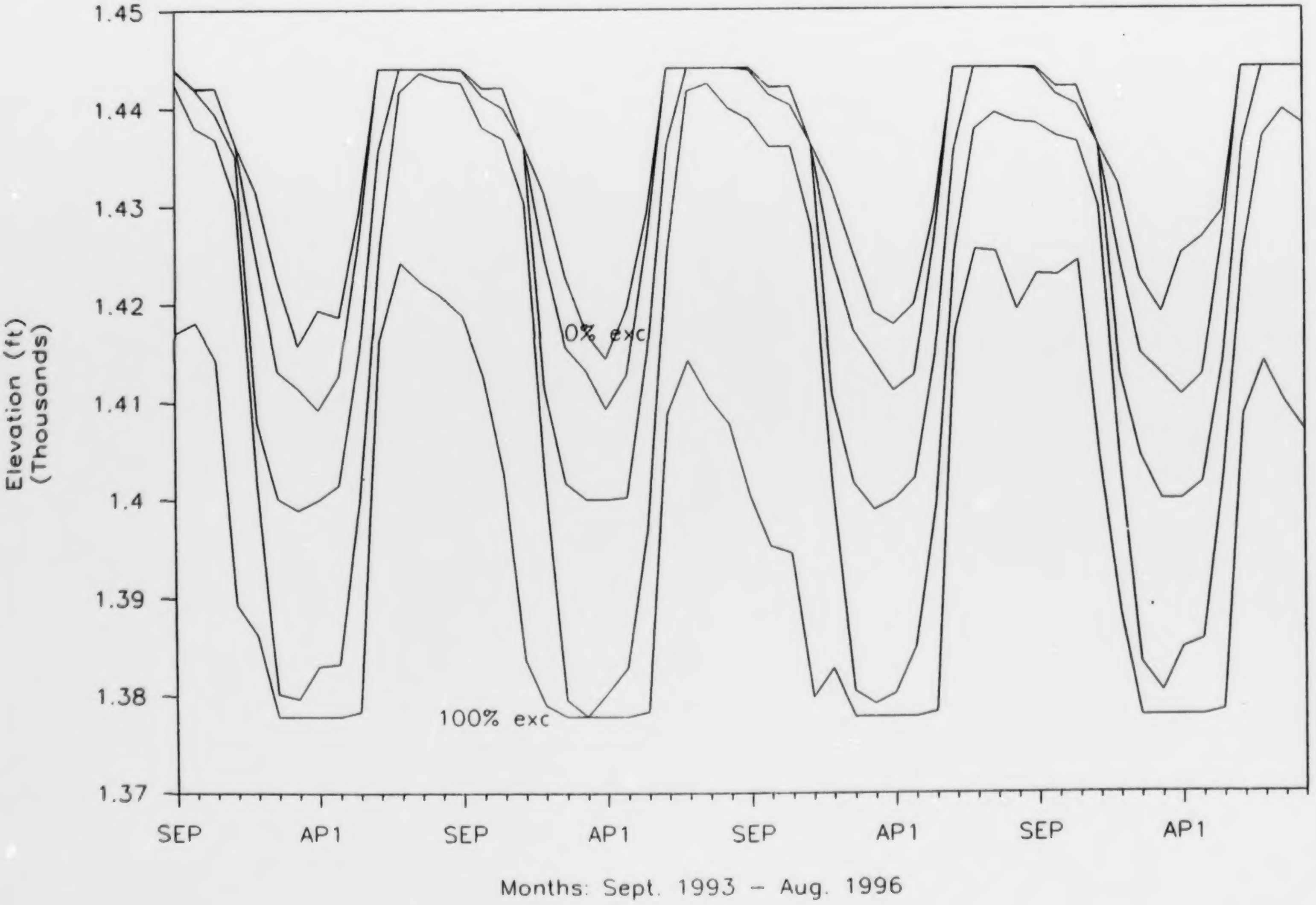

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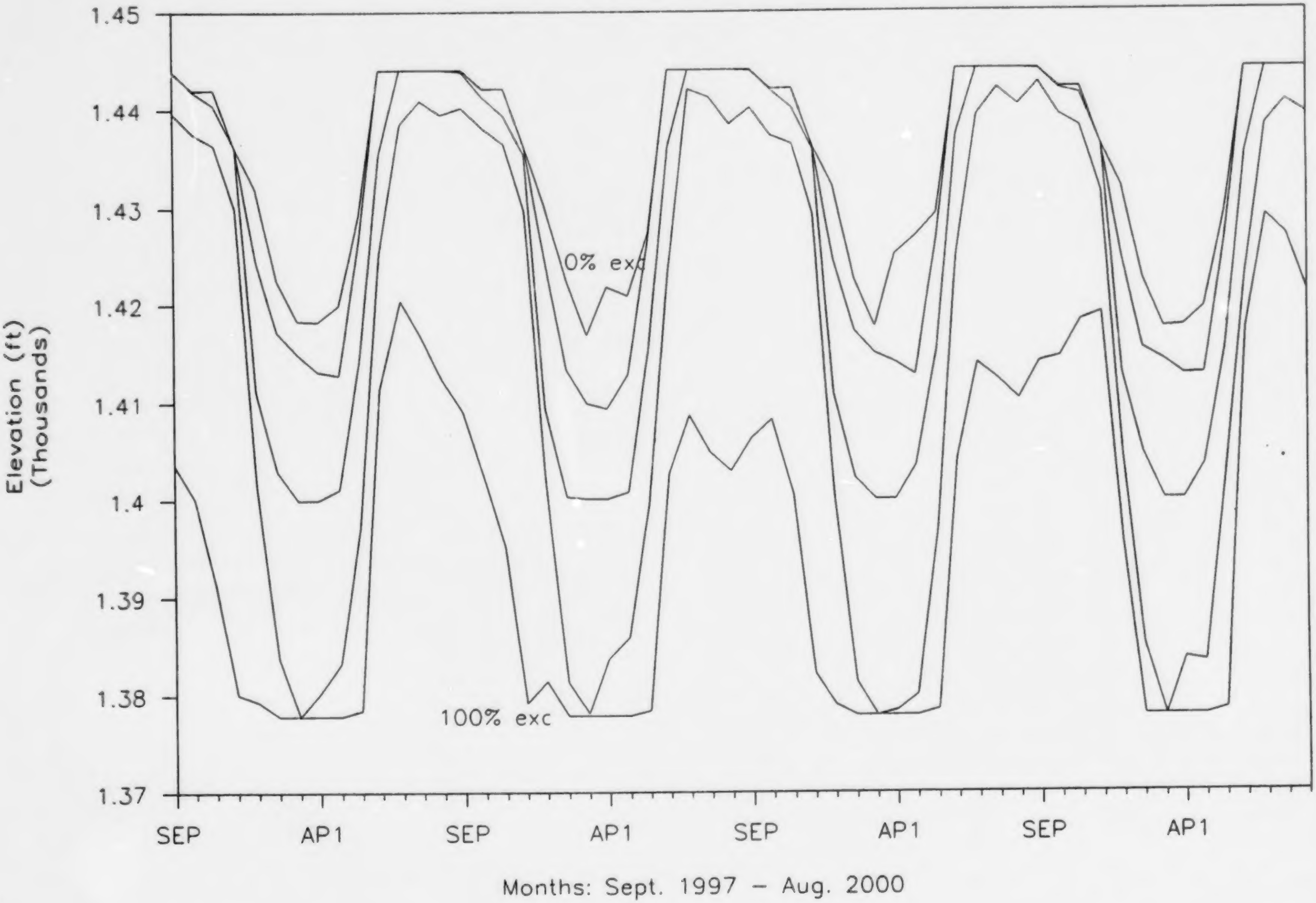
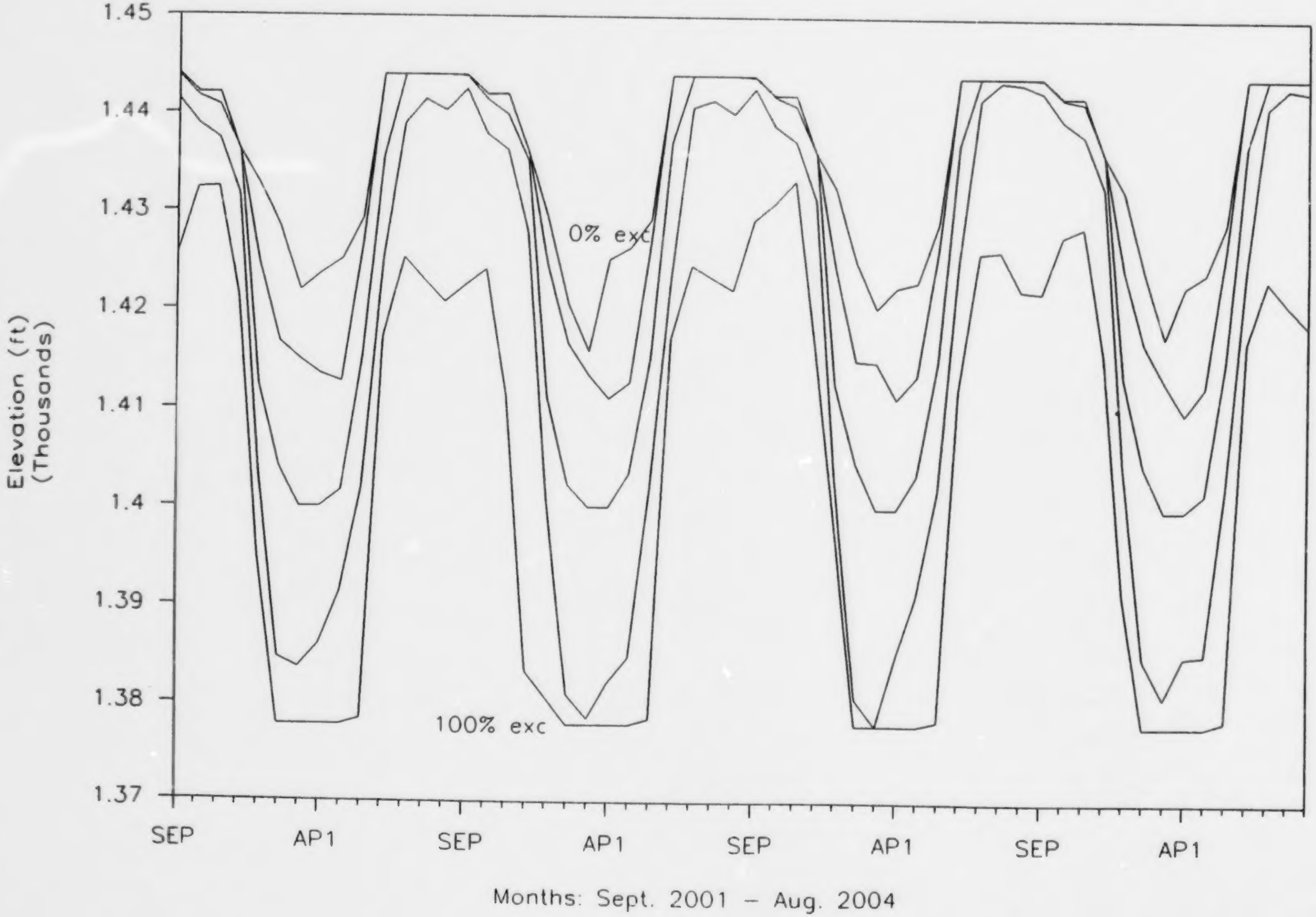


Figure A8.2.14 Elevations at Arrow Lakes Reservoir, Regime 1 (ARO): September 2001 - August 2004



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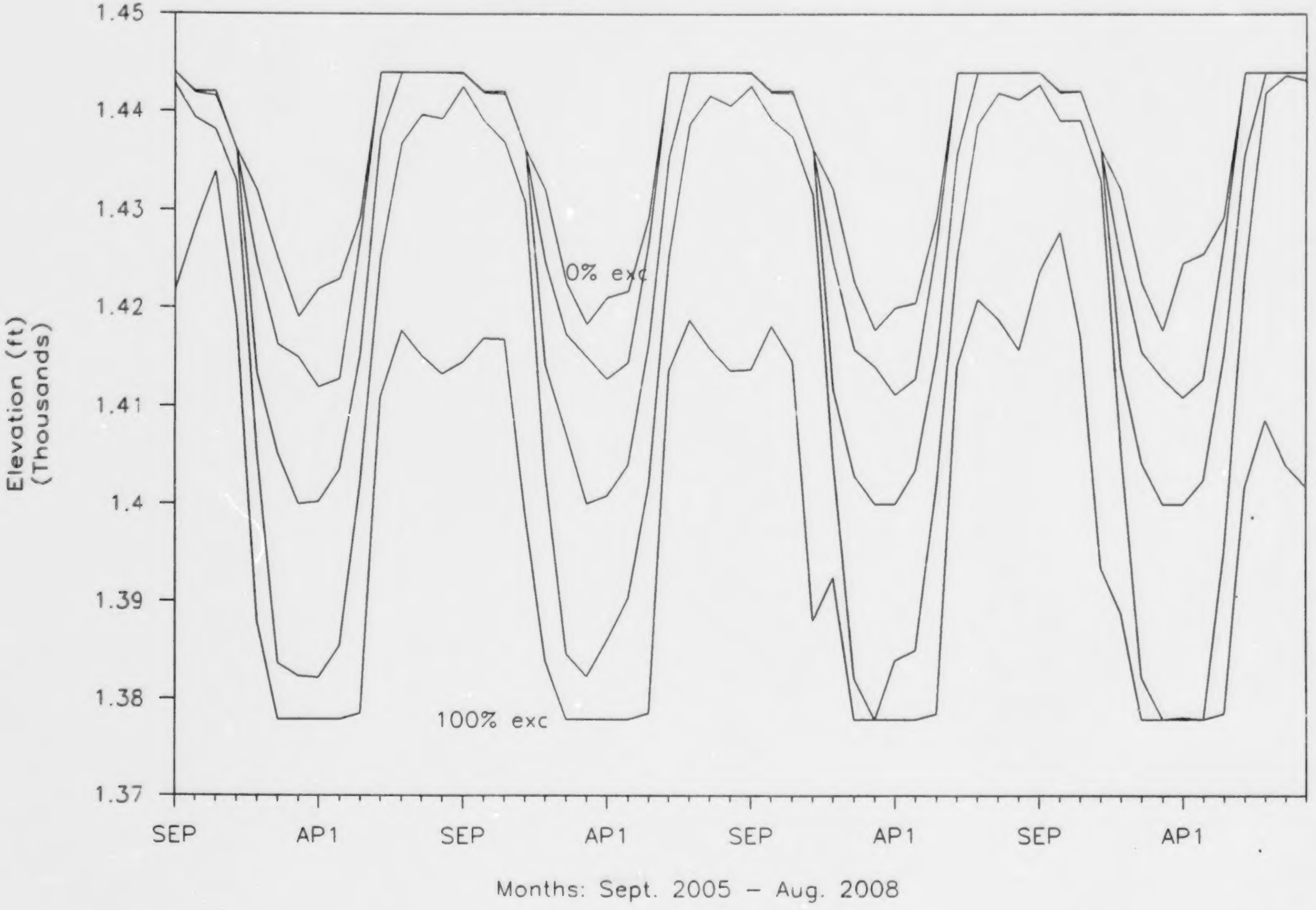

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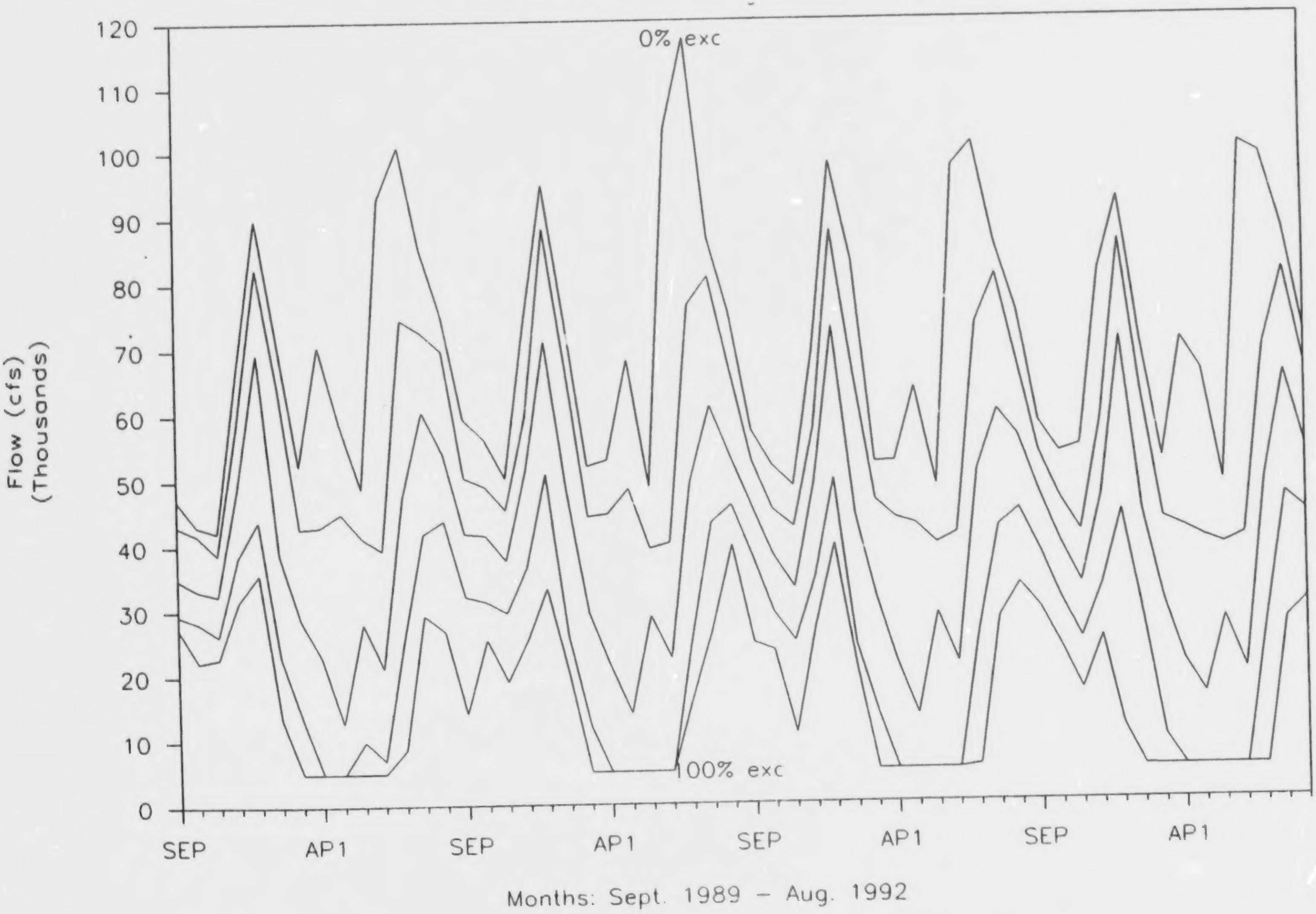


Figure A8.2.17 Flows at Arrow Lakes Reservoir, Regime 1 (ARO): September 1993 - August 1996

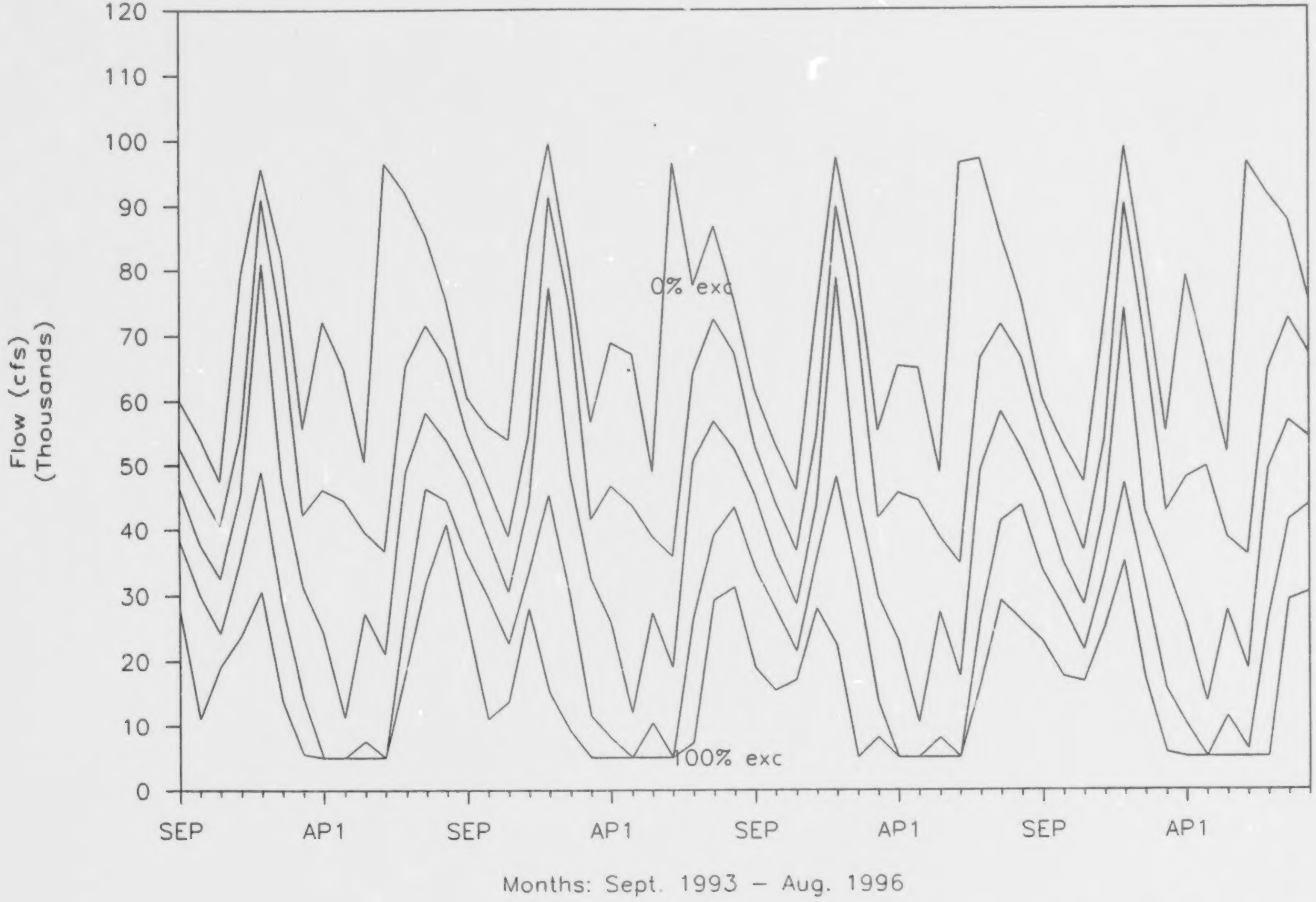
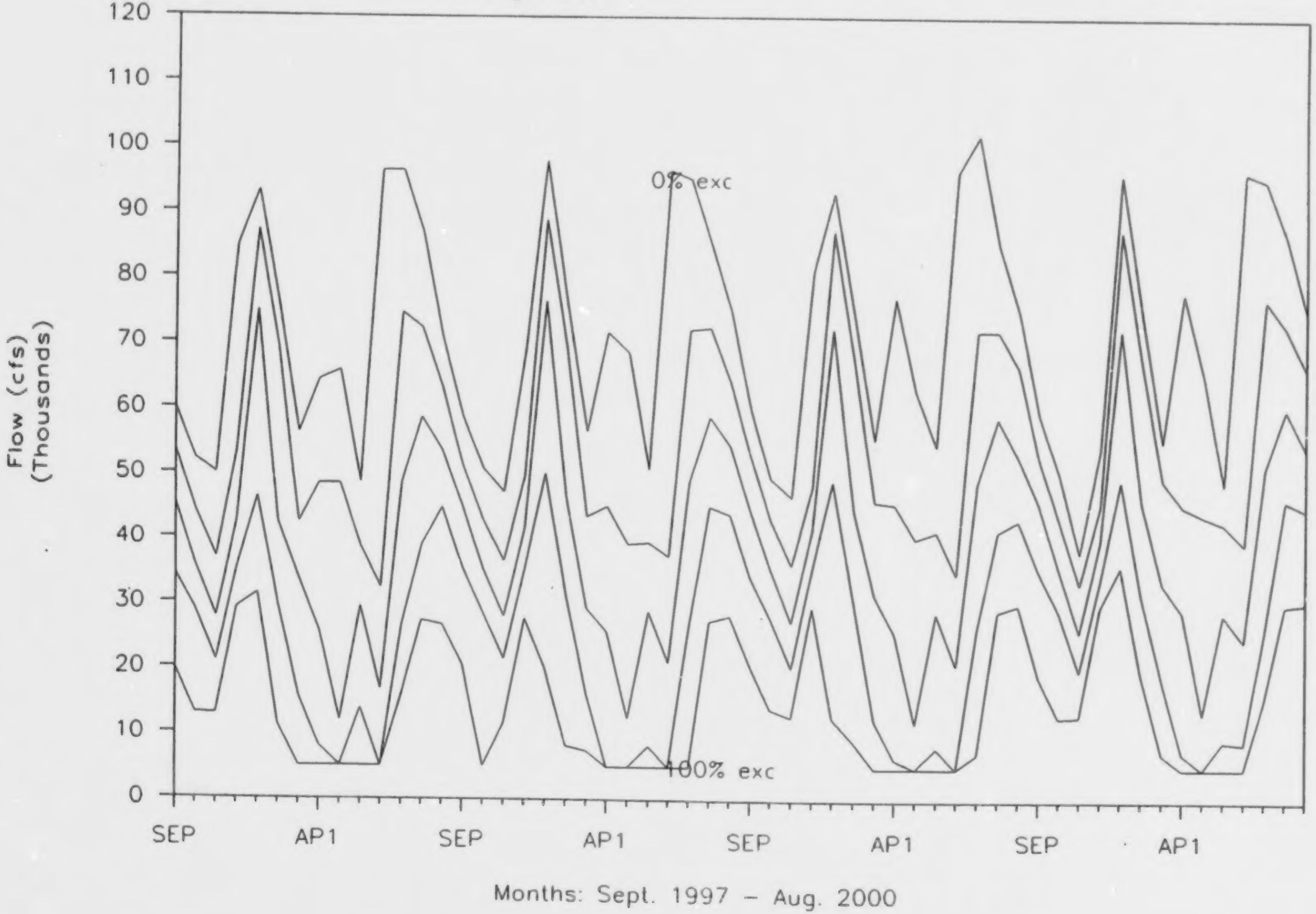


Figure A8.2.18 Flows at Arrow Lakes Reservoir, Regime 1 (ARO): September 1997 - August 2000



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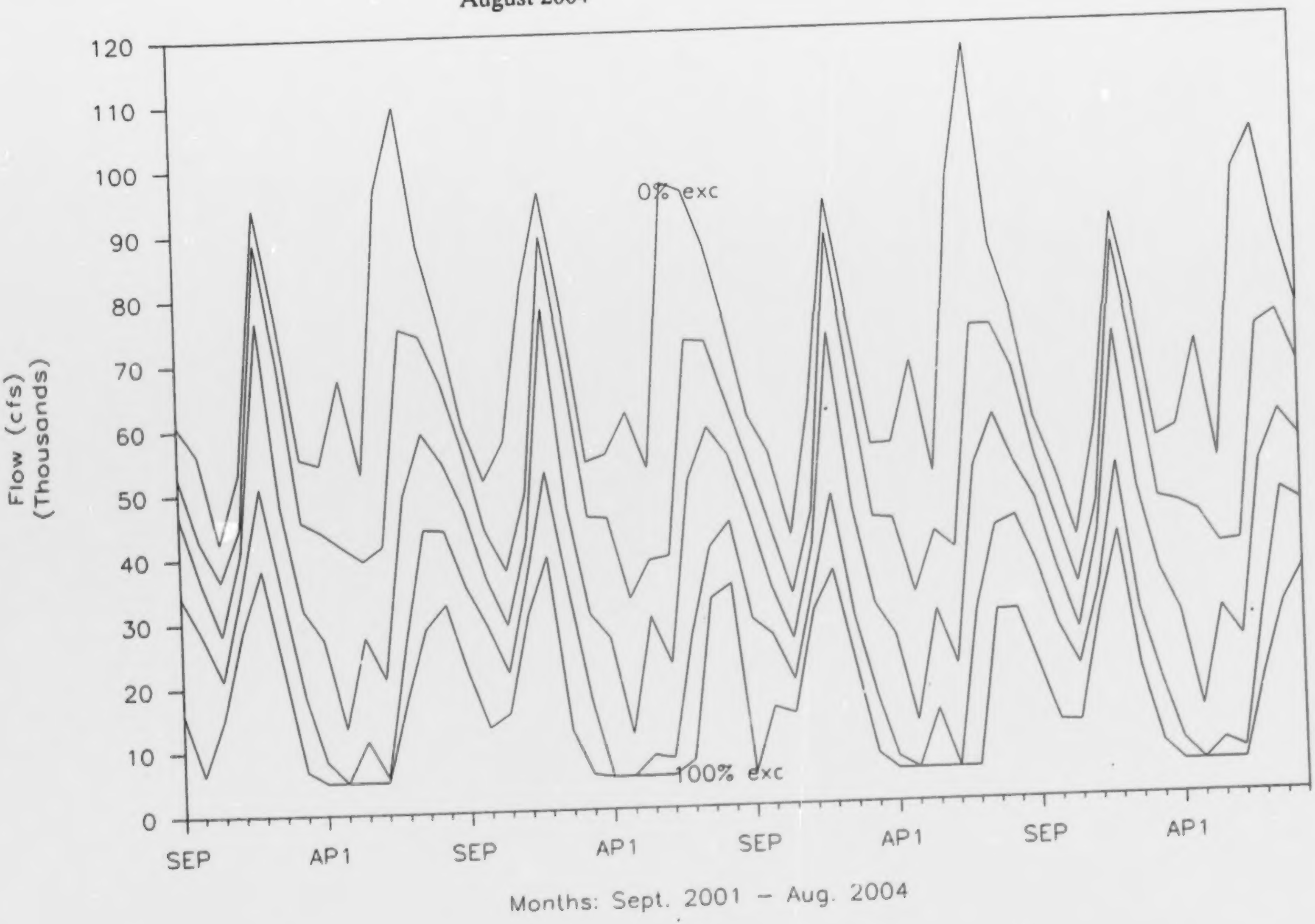

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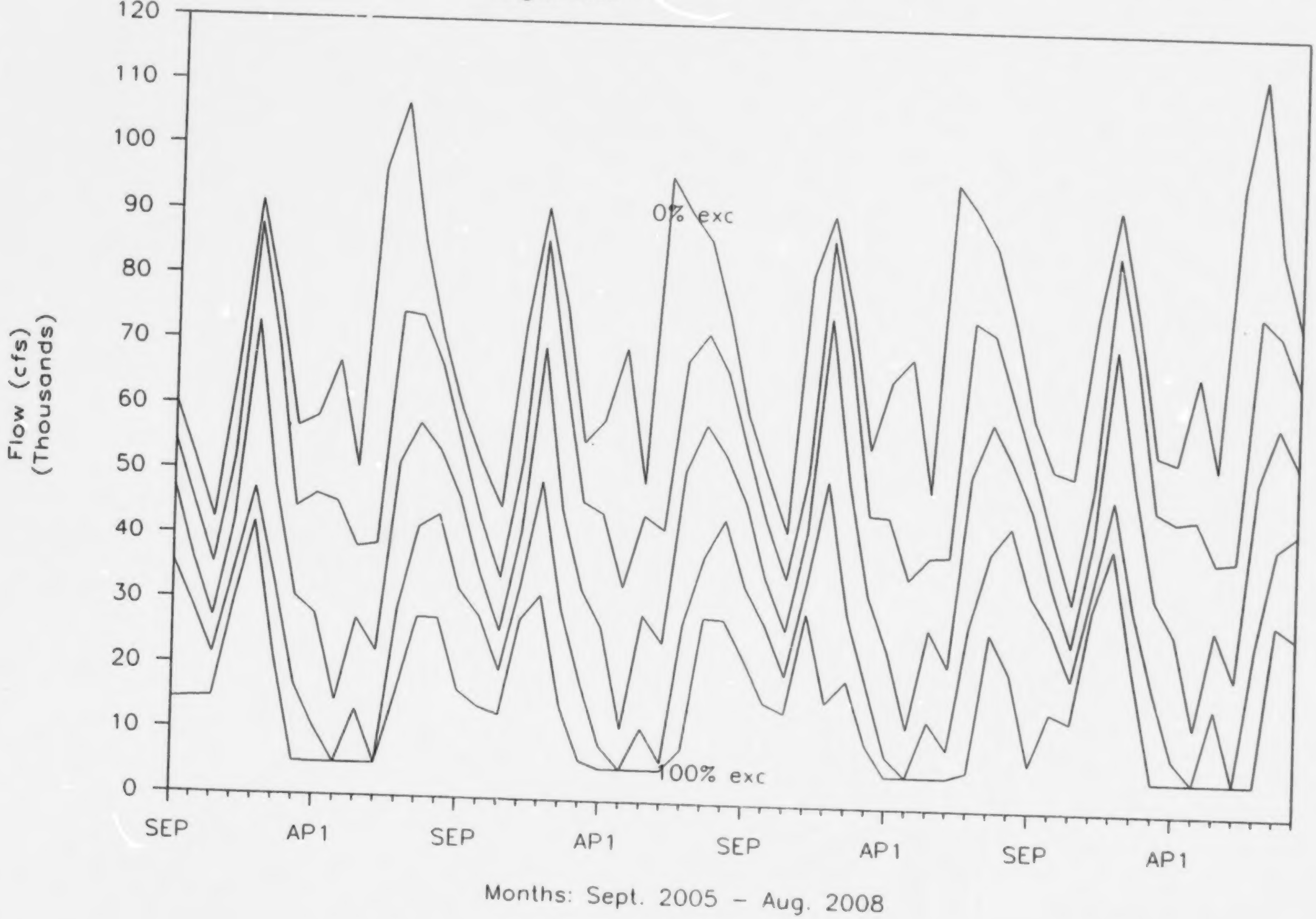


APPENDIX 9

Alternate Operating Scenario (AOS)
Summary Hydrographs
1989 - 2008

9.1 Base Case (AOS)
9.2 Regime 1 (AOS)

APPENDIX 9.1

Base Case (AOS)

Figure A9.1.1 Elevations at Mica Reservoir, Base Case (AOS): September 1989 - August 1992

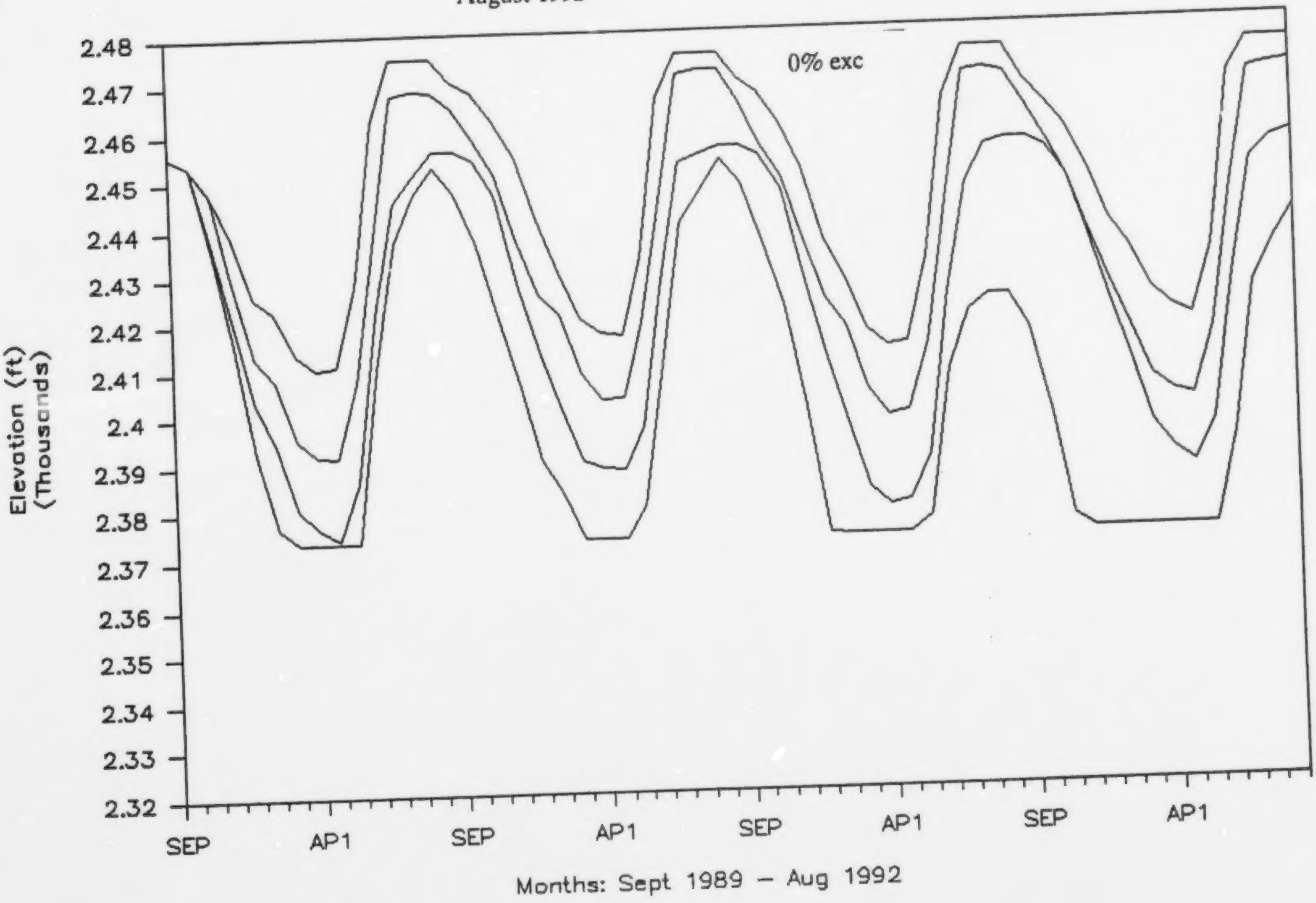


Figure A9.1.2 Elevations at Mica Reservoir, Base Case (AOS) : September 1993 - August 1996

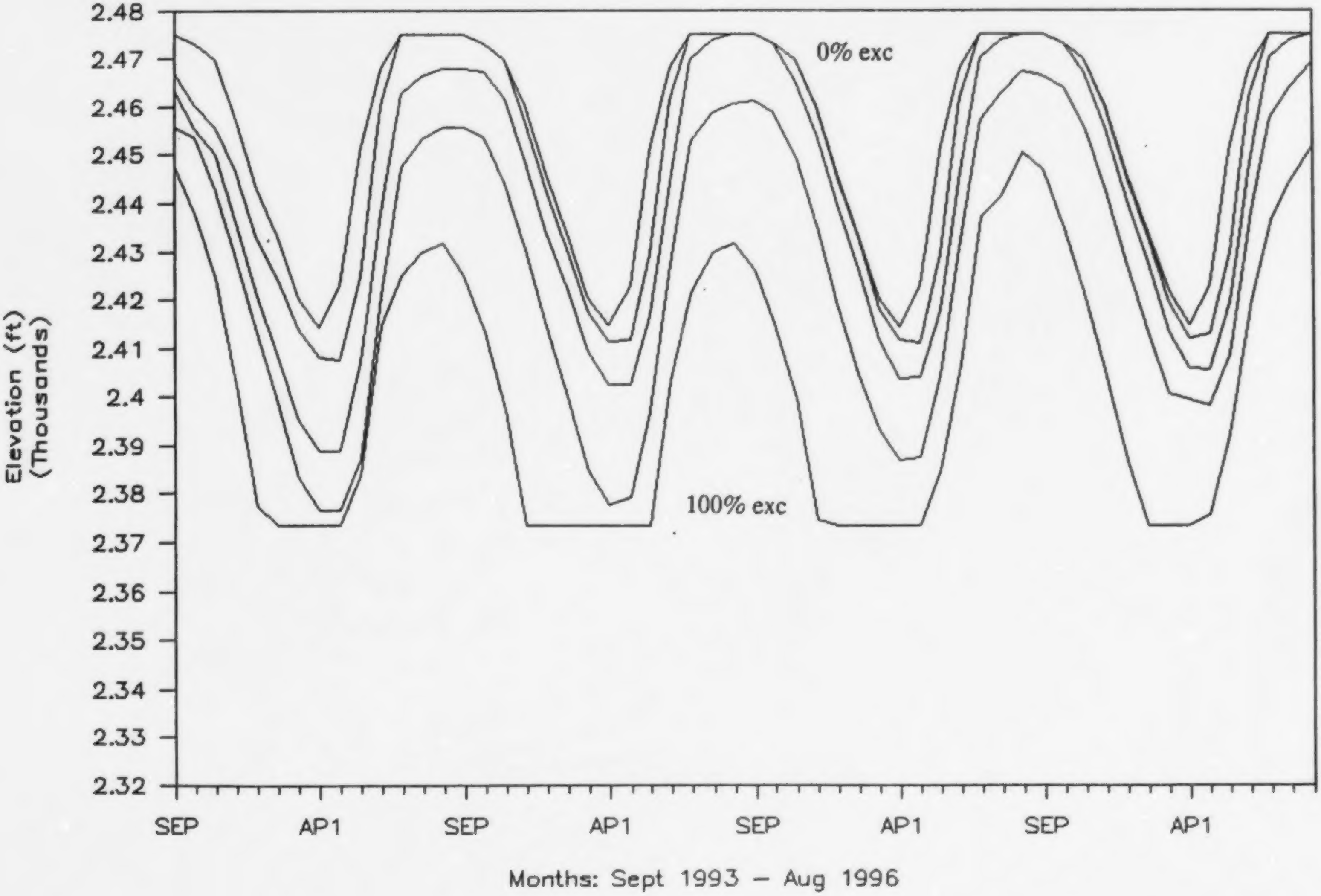
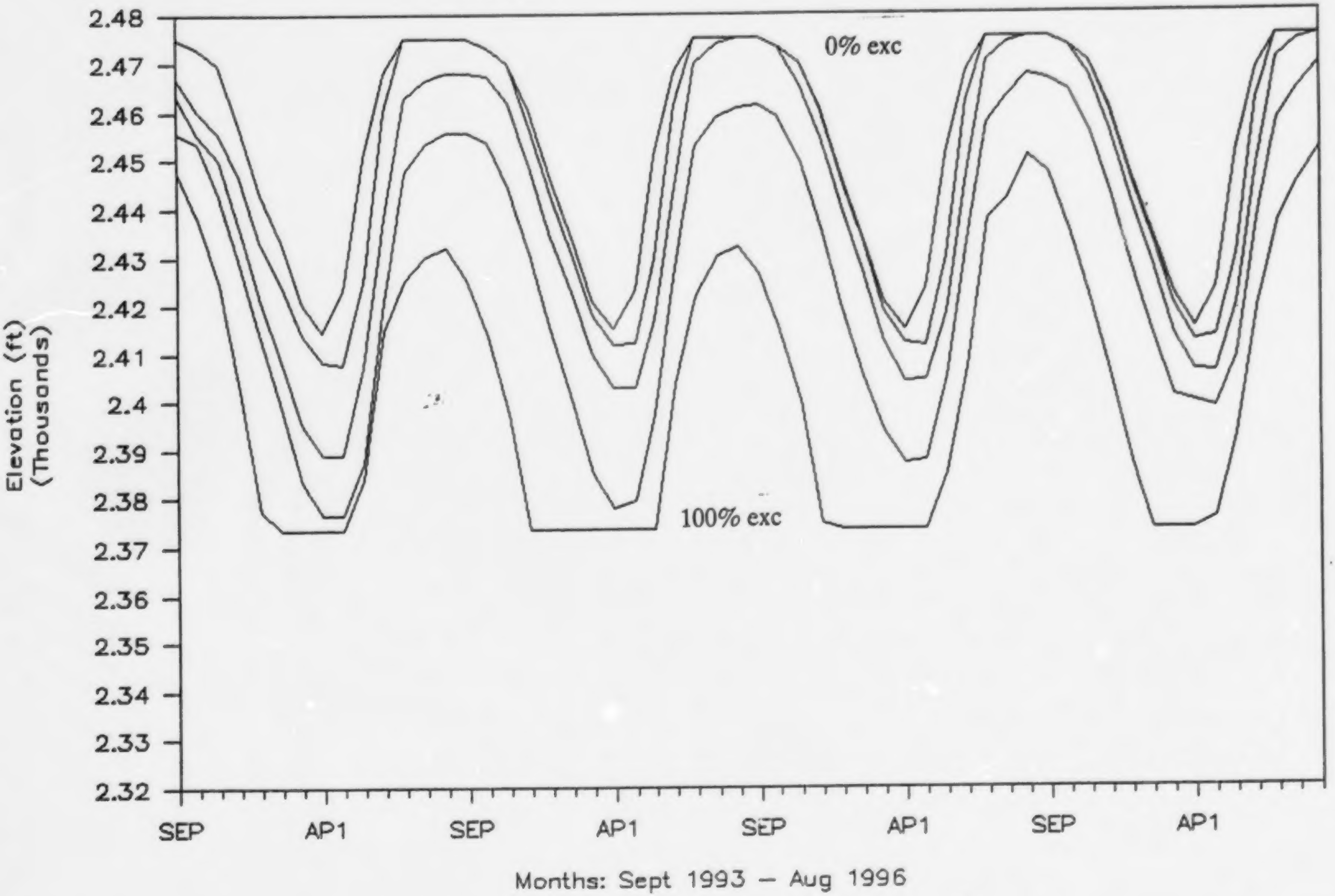


Figure A9.1.3 Elevations at Mica Reservoir, Base Case (AOS) : September 1997 - August 2000



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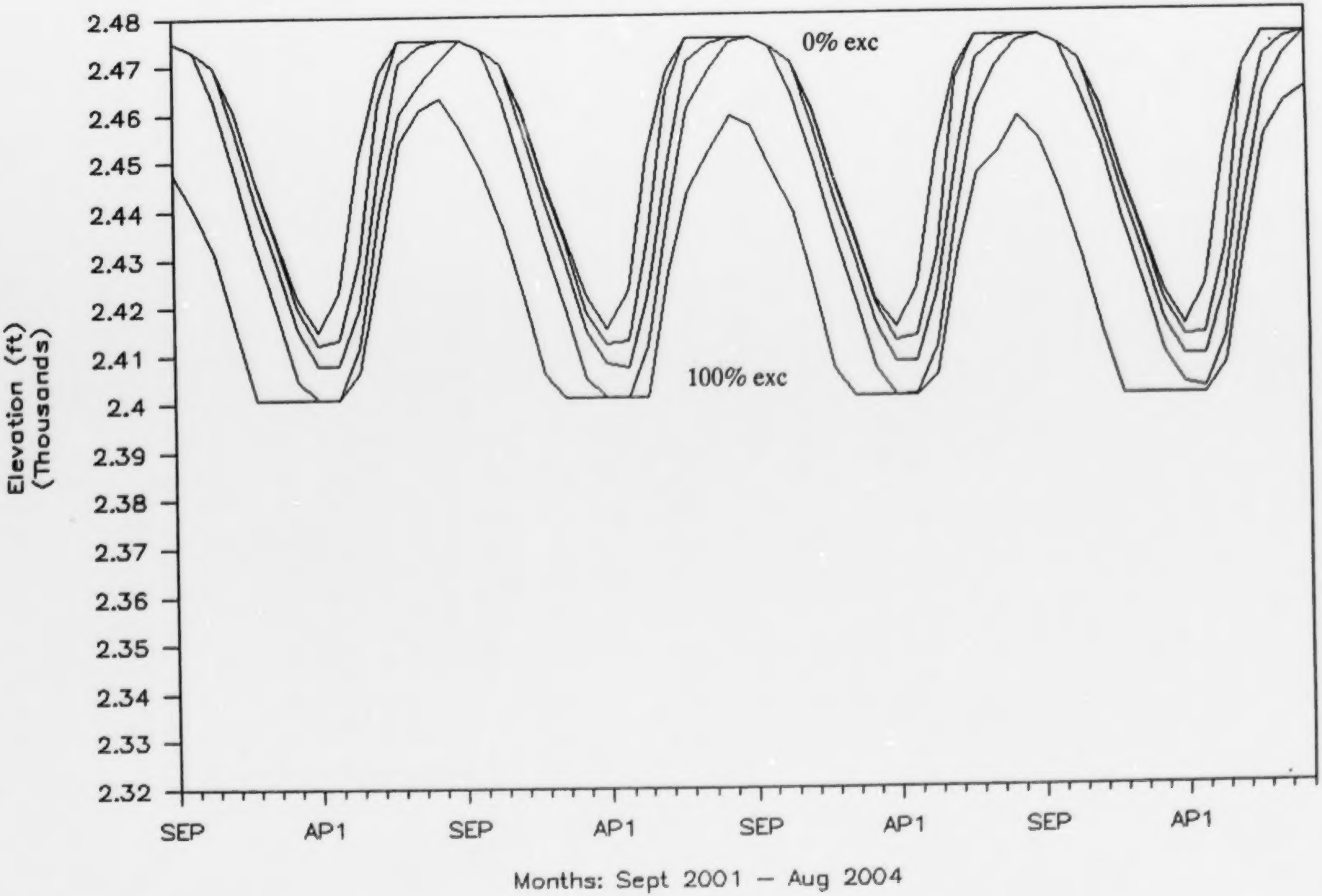


Figure A9.1.5 Elevations at Mica Reservoir, Base Case (AOS): September 2005 - August 2008

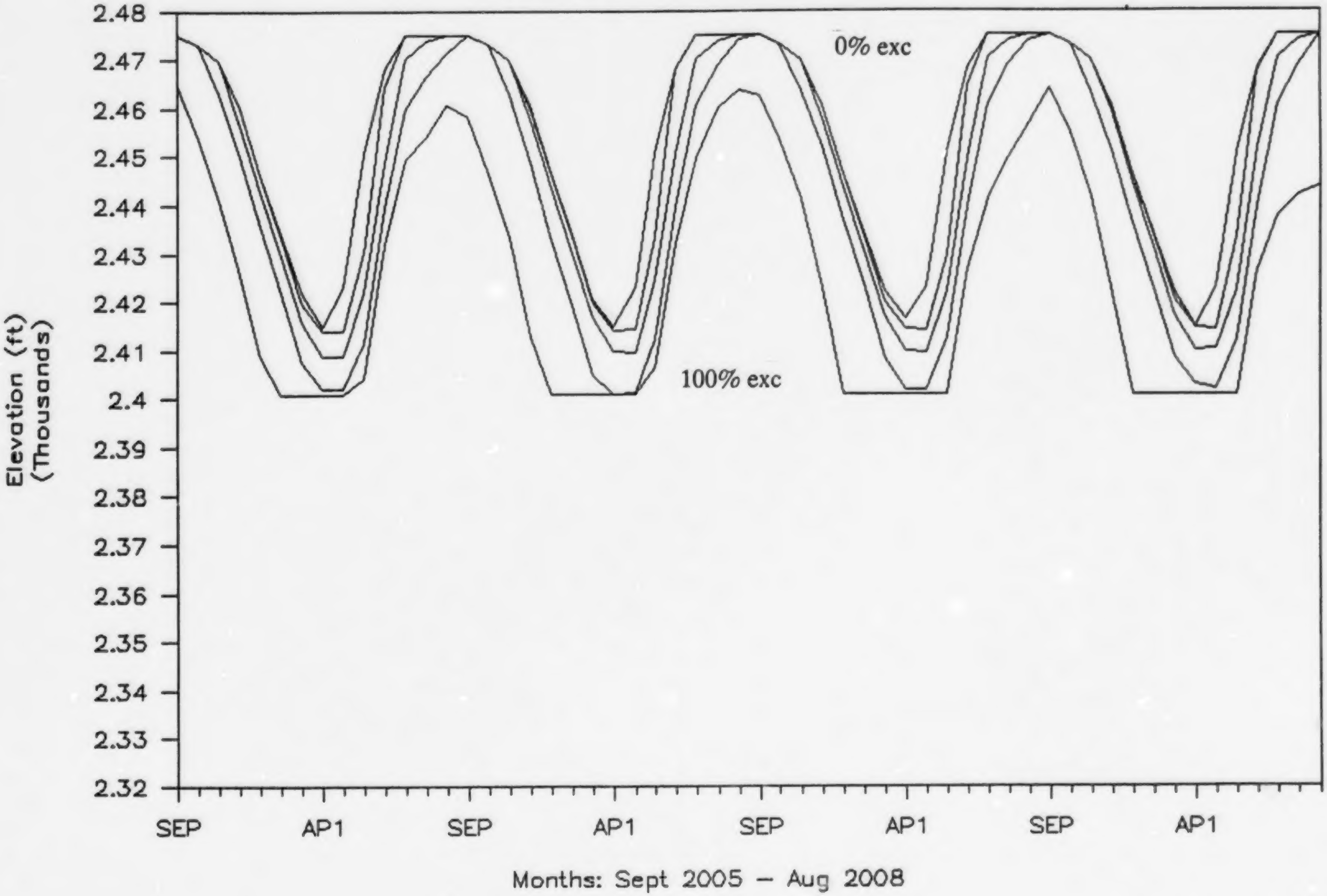


Figure A9.1.6 Flows at Mica Reservoir, Base Case (AOS) : September 1989 - August 1992

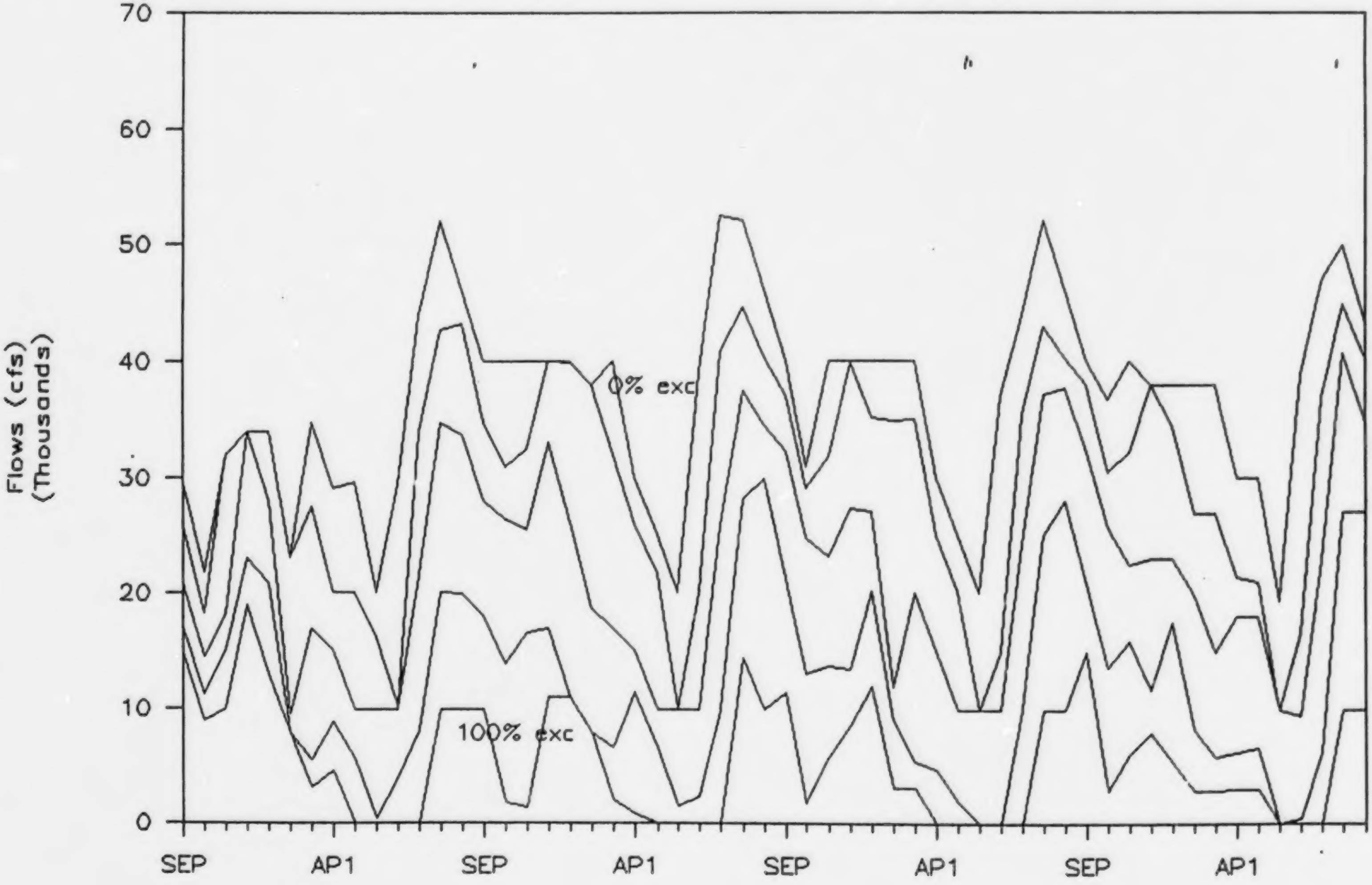


Figure A9.1.7 Flows at Mica Reservoir, Base Case (AOS): September 1993 - August 1996

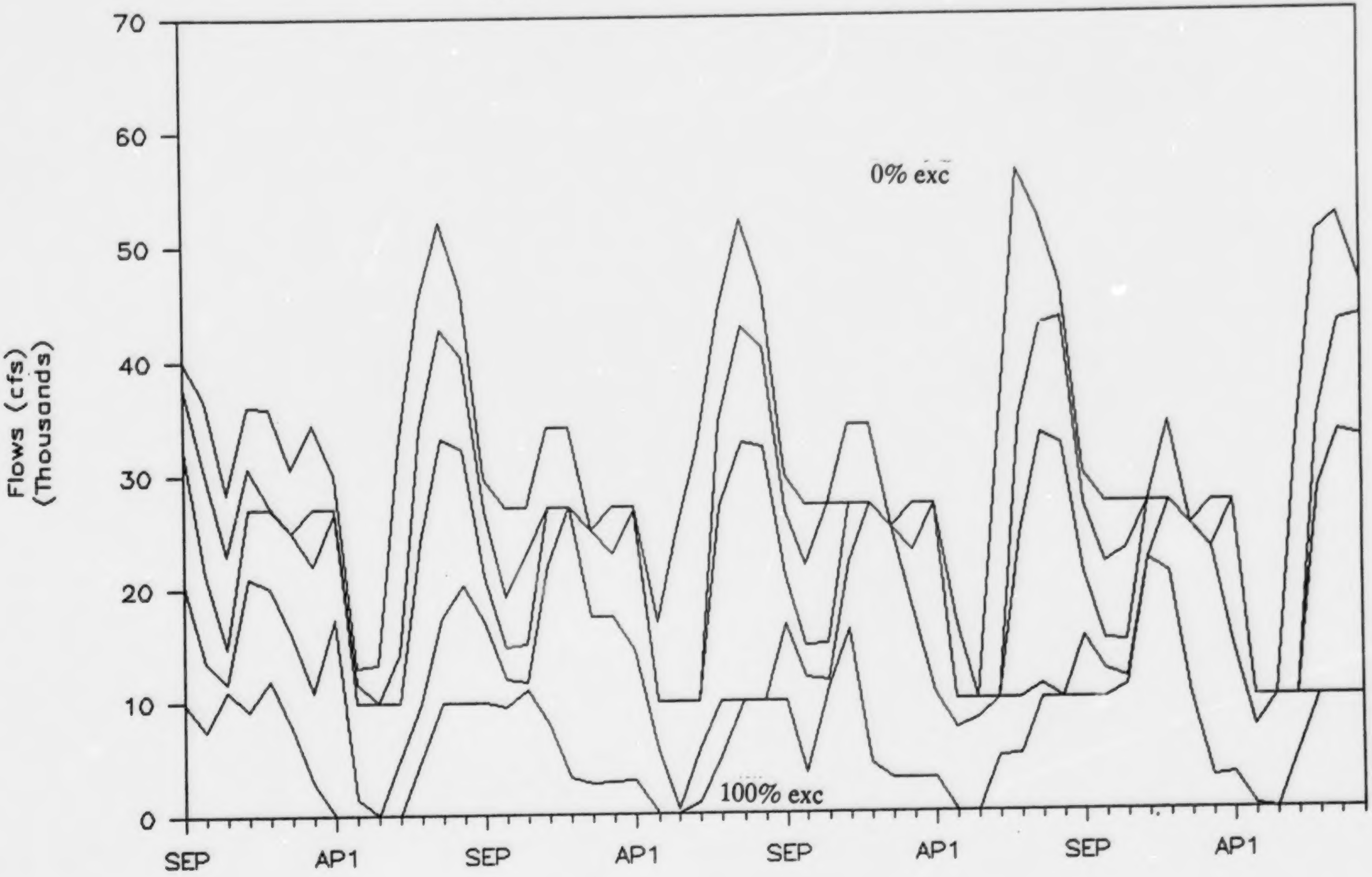


Figure A9.1.8 Flows at Mica Reservoir, Base Case (AOS): September 1997 - August 2000

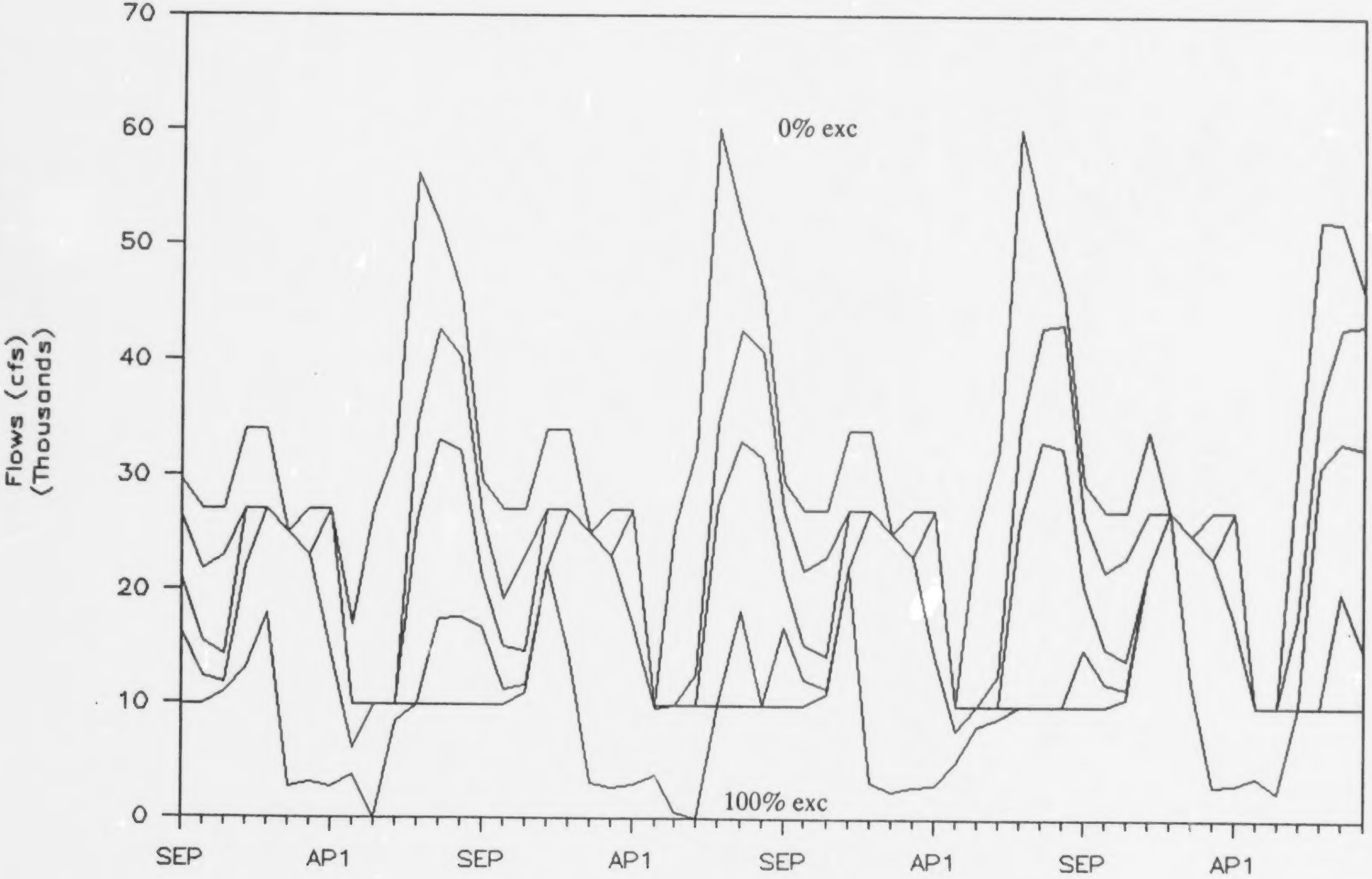


Figure A9.1.9 Flows at Mica Reservoir, Base Case (AOS): September 2001 - August 2004

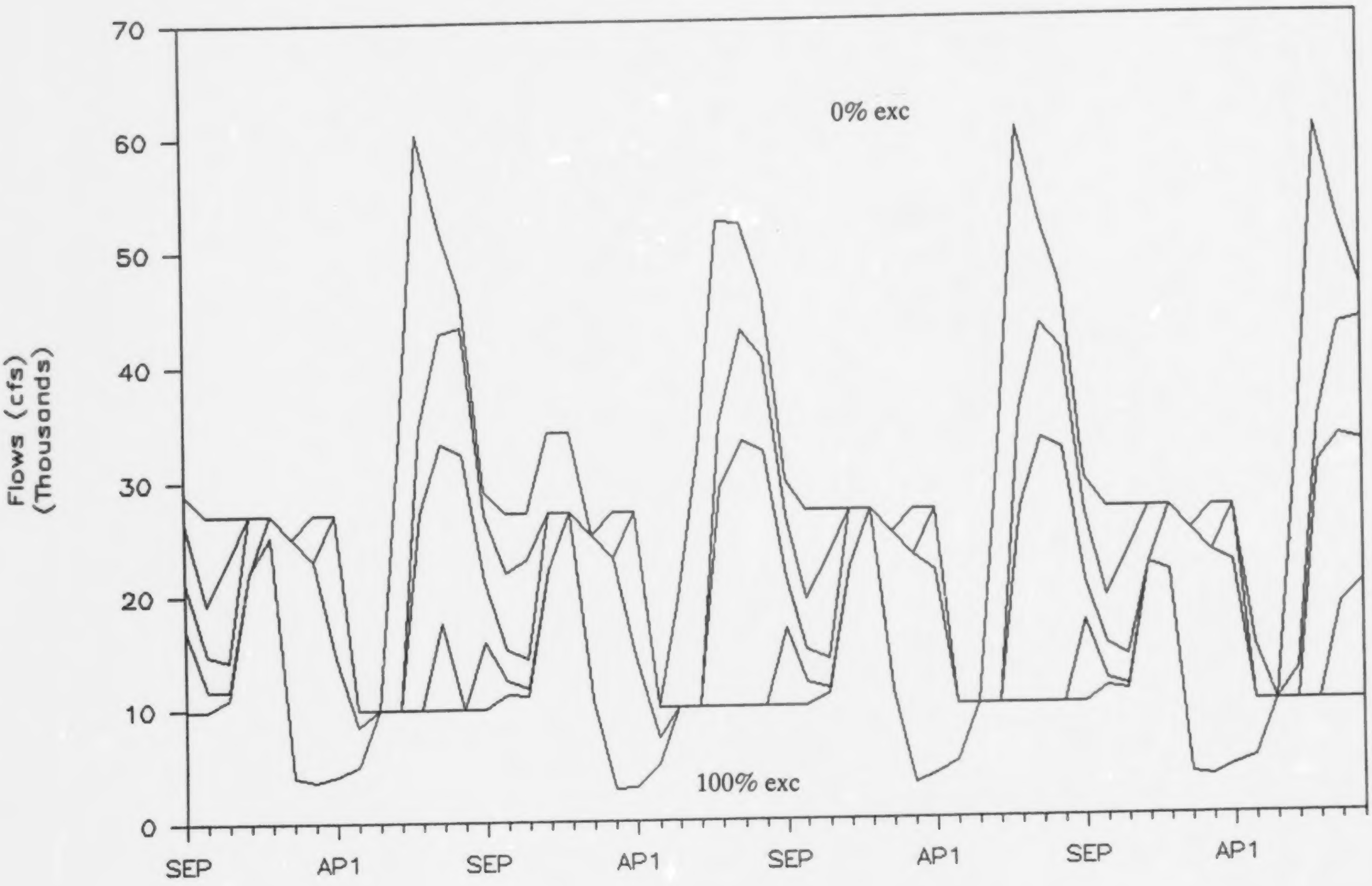


Figure A9.1.10 Flows at Mica Reservoir, Base Case (AOS): September 2005 - August 2008

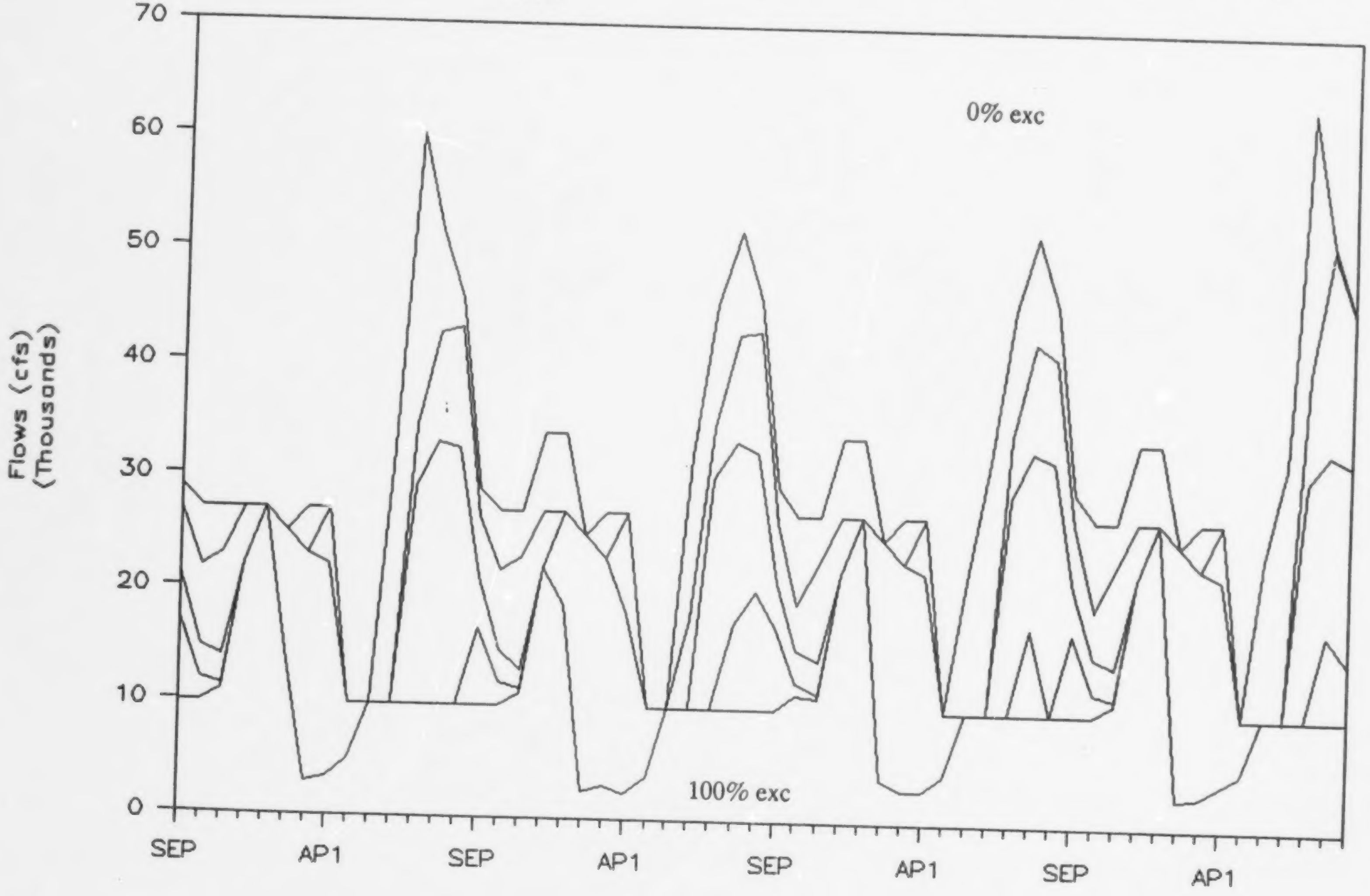


Figure A9.1.11 Elevations at Arrow Lakes Reservoir, Base Case (AOS): September 1989 - August 1992

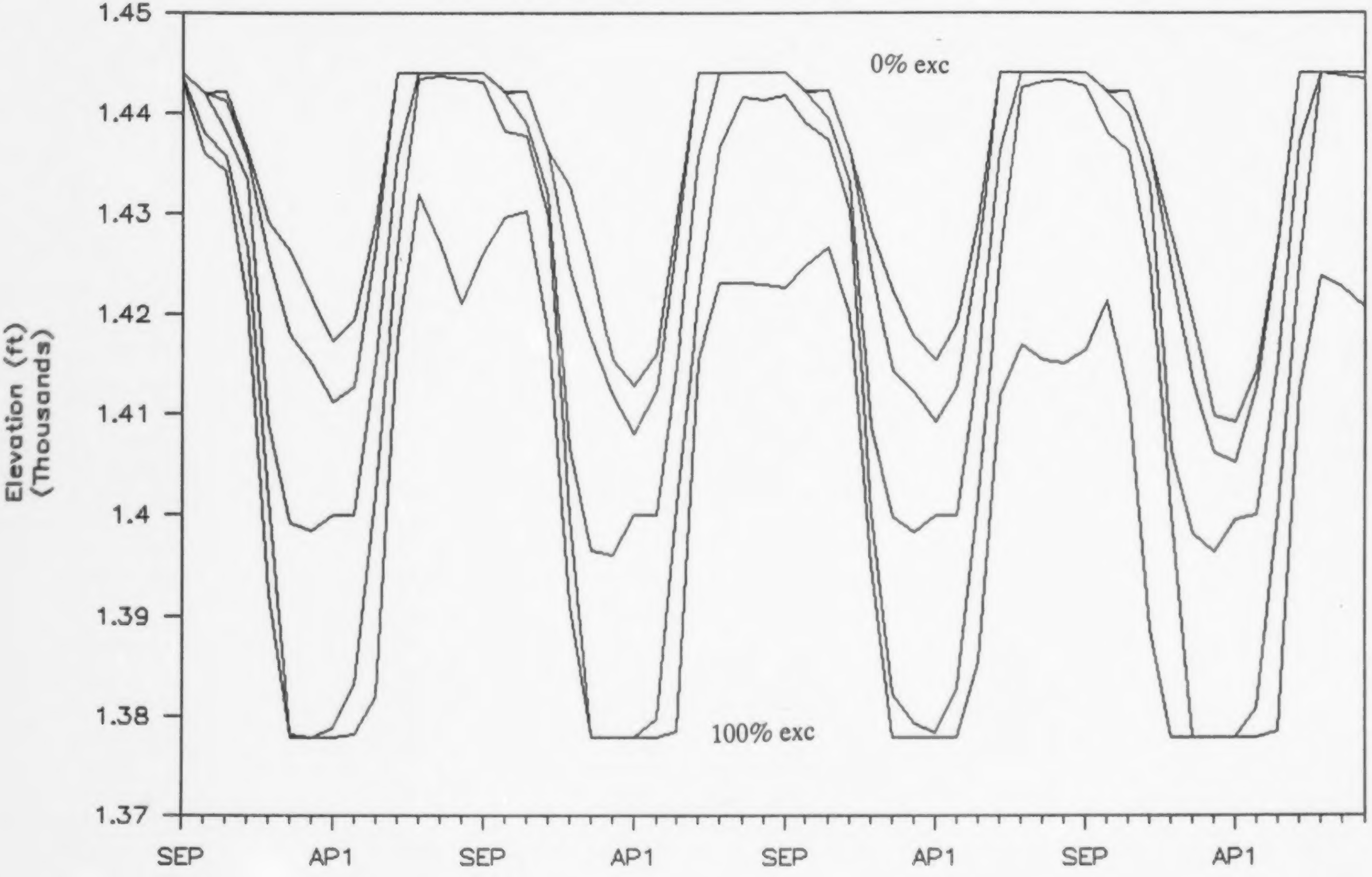


Figure A9.1.12 Elevations at Arrow Lakes Reservoir, Base Case (AOS): September 1993 - August 1996

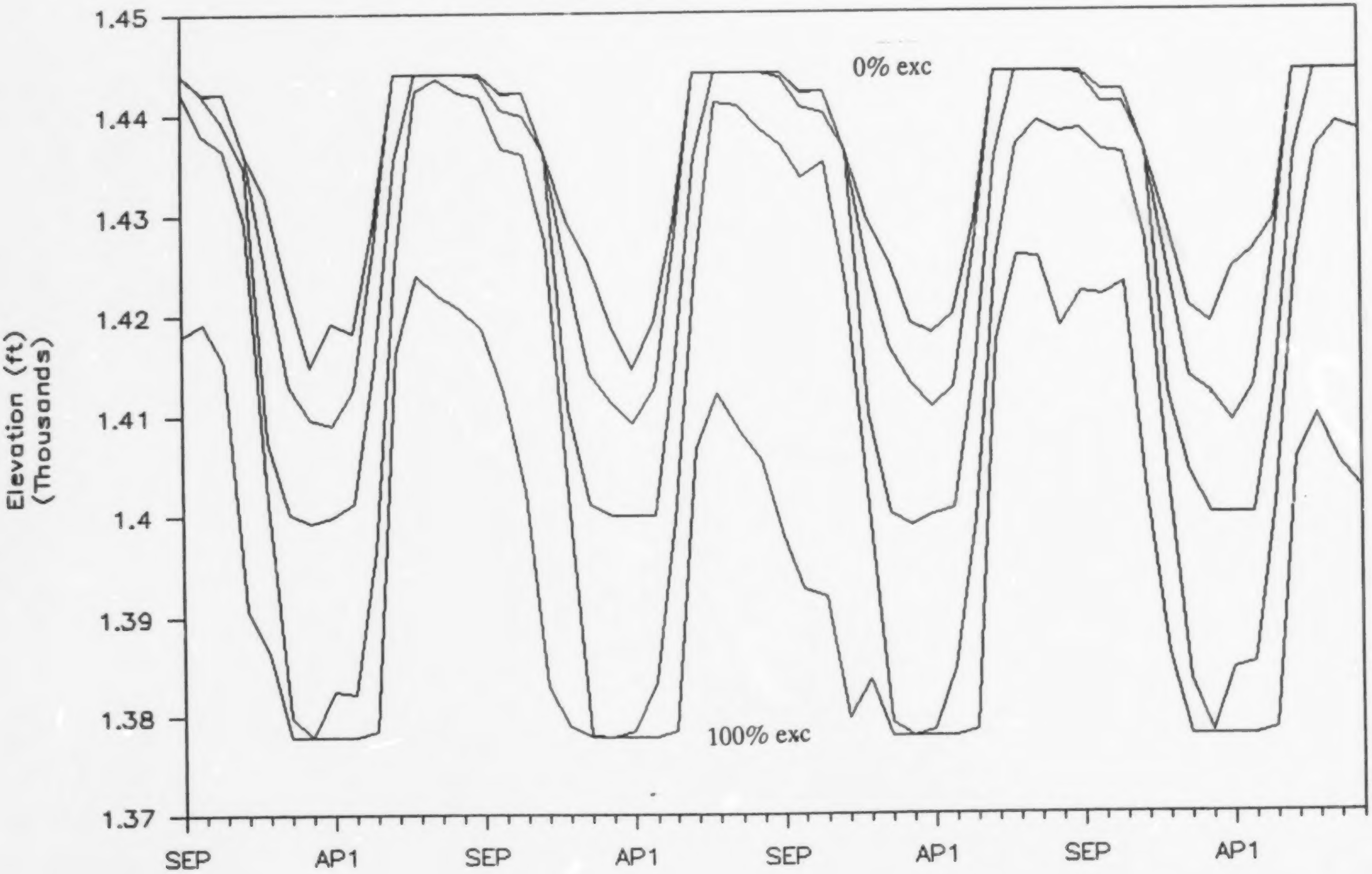


Figure A9.1.13 Elevations at Arrow Lakes Reservoir, Base Case (AOS): September 1997 - August 2000

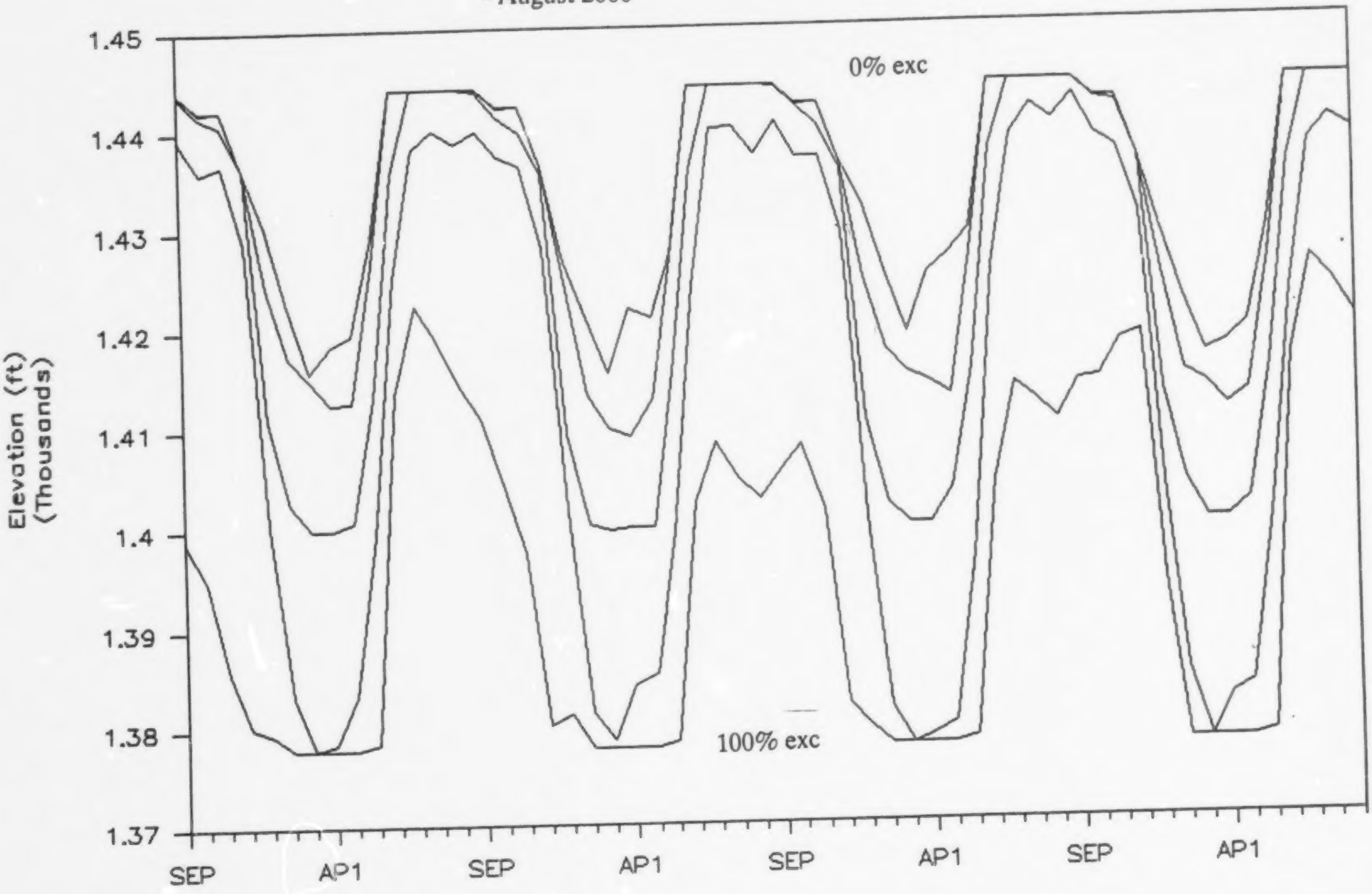
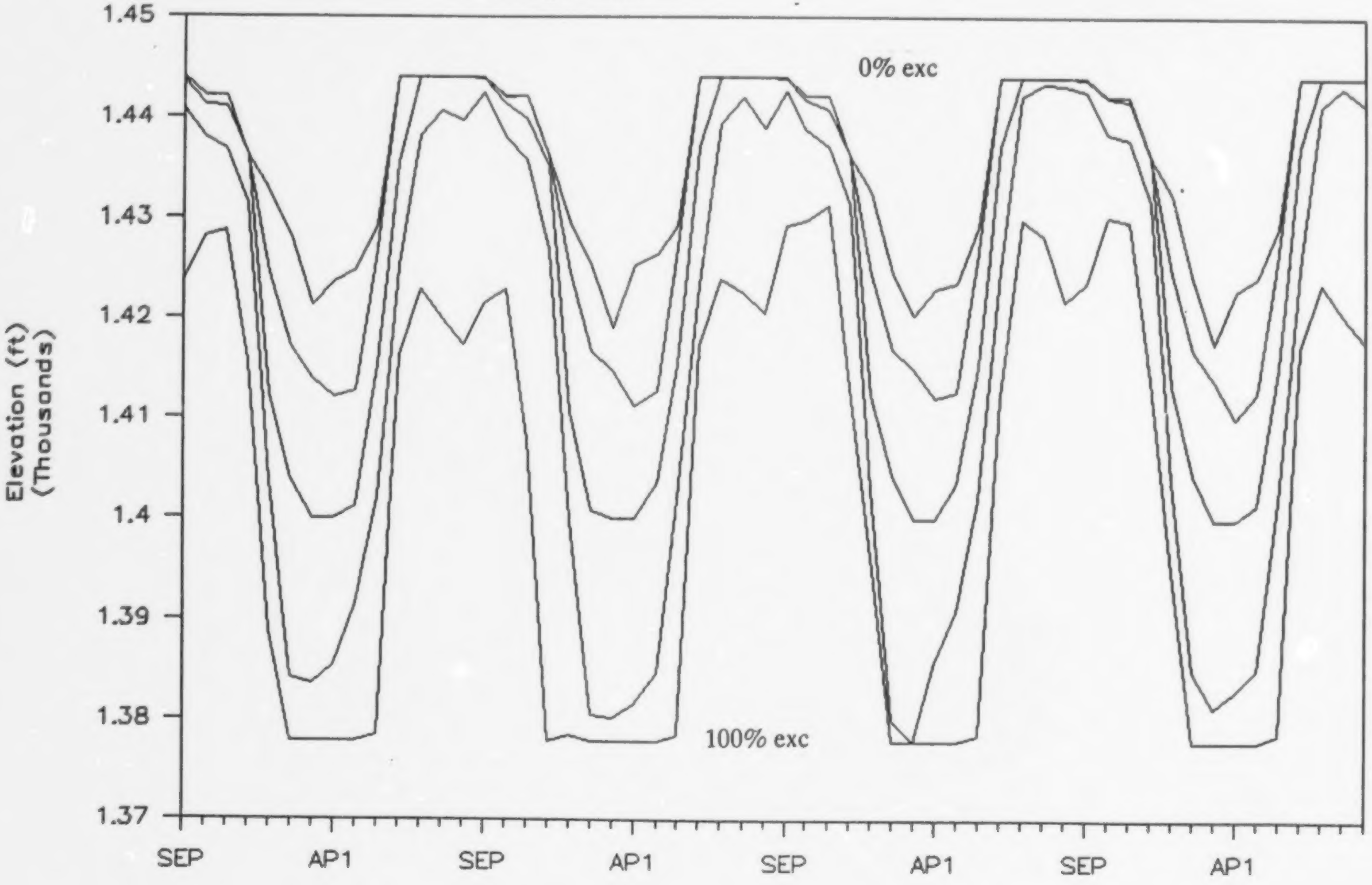


Figure A9.1.14 Elevations at Arrow Lakes Reservoir, Base Case (AOS): September 2001 - August 2004



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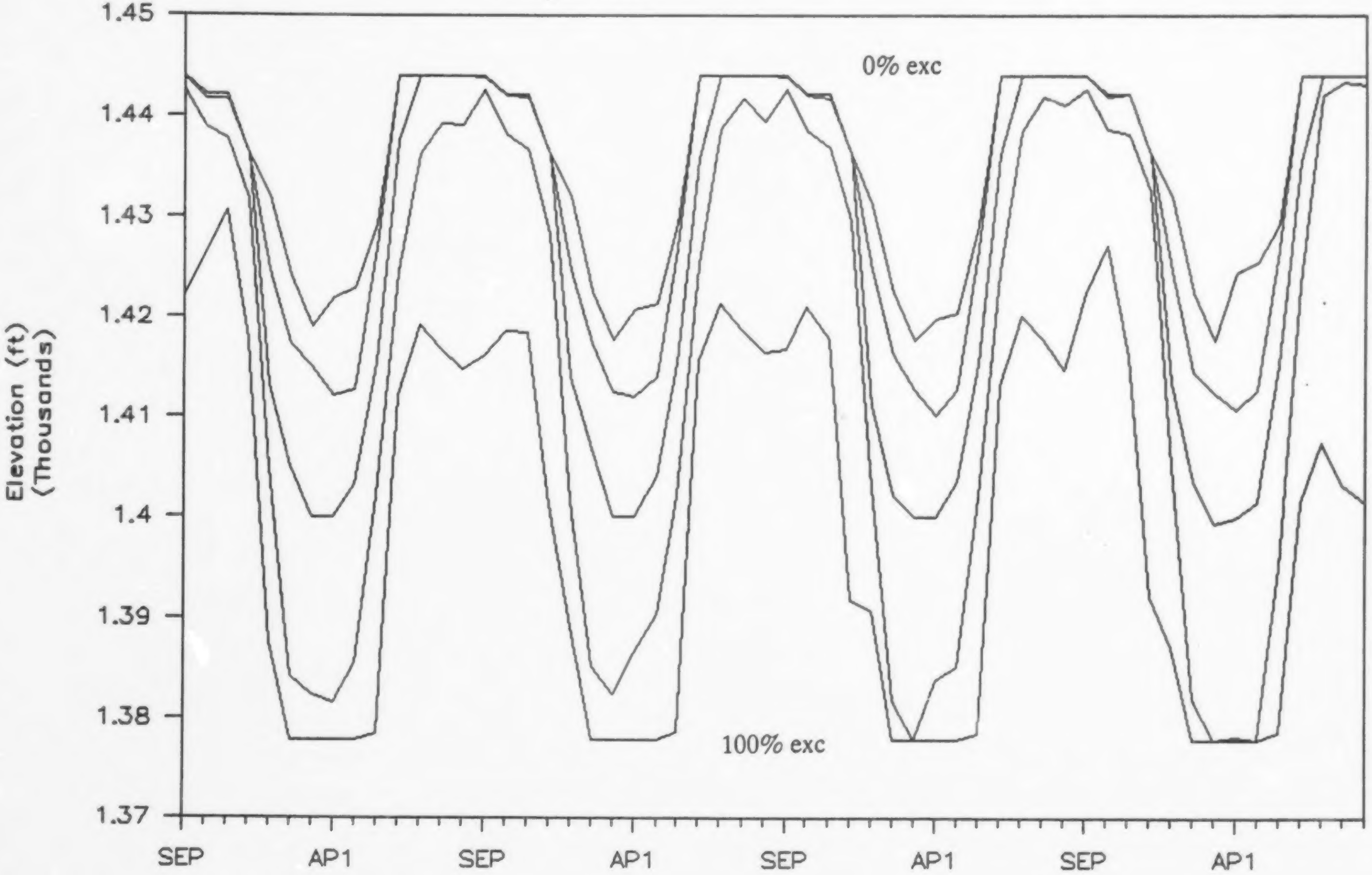


Figure A9.1.16 Flows at Arrow Lakes Reservoir, Base Case (AOS): September 1989 - August 1992

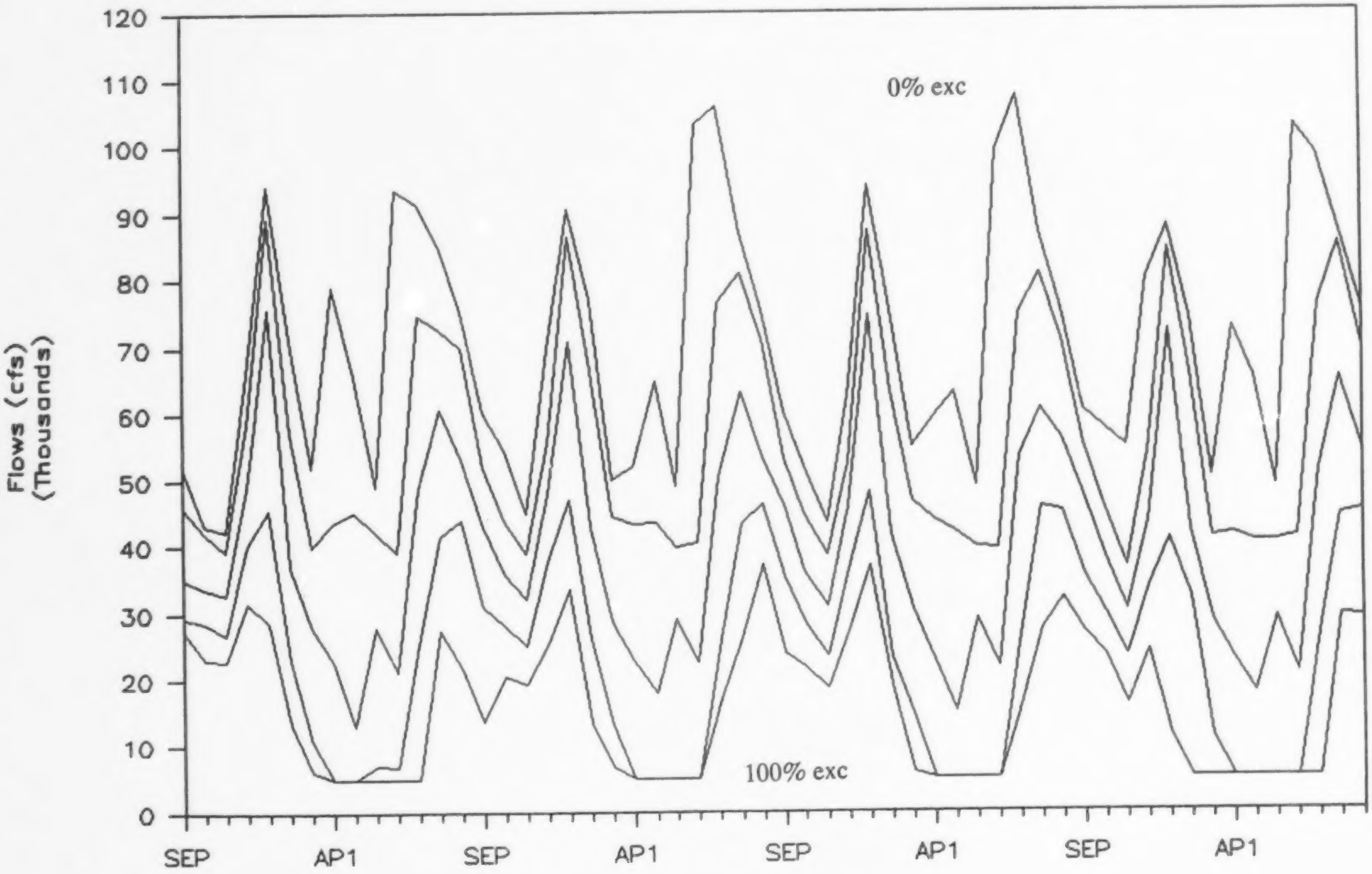


Figure A9.1.17 Flows at Arrow Lakes Reservoir, Base Case (AOS): September 1993 - August 1996

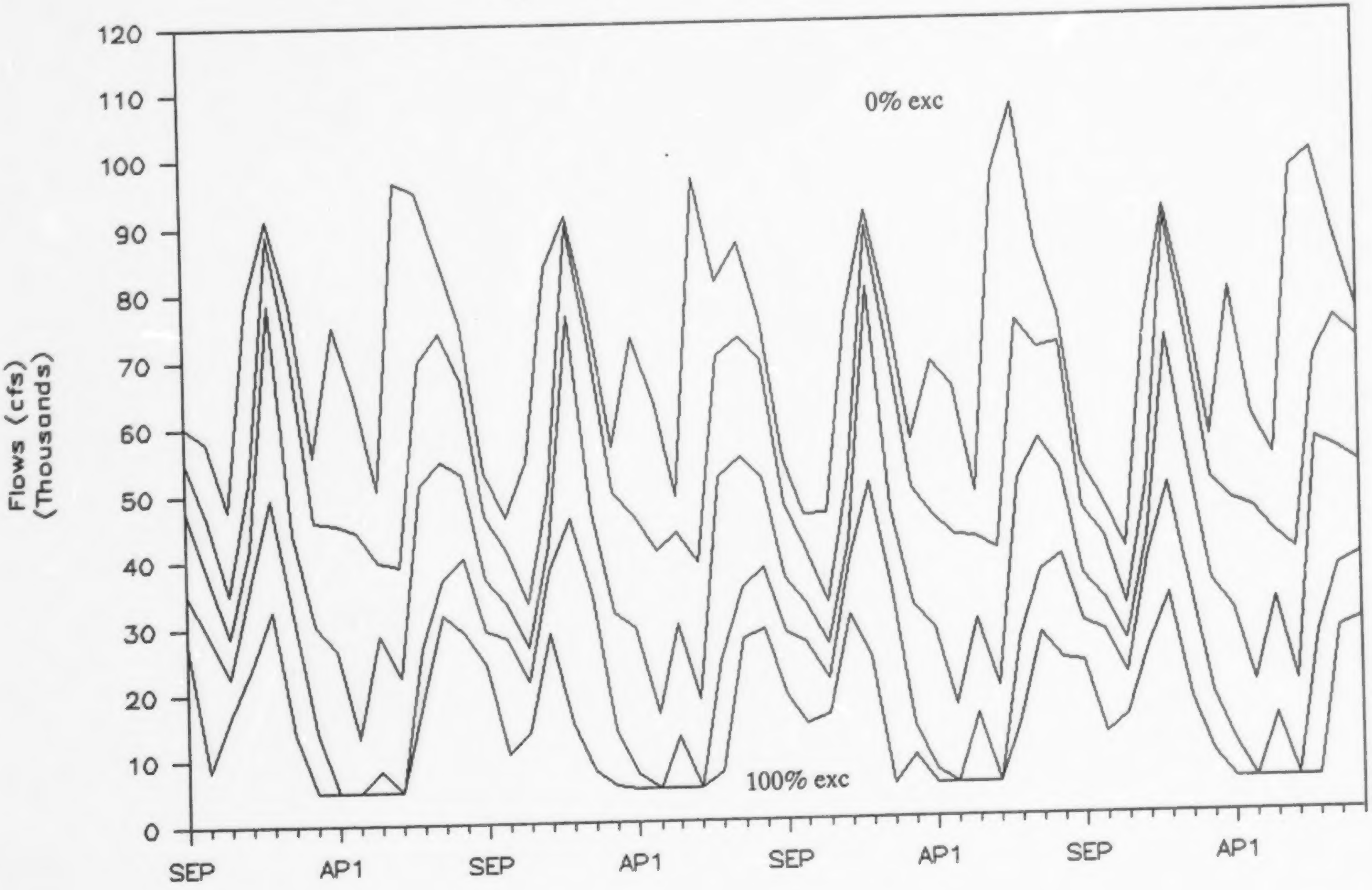


Figure A9.1.18 Flows at Arrow Lakes Reservoir, Base Case (AOS): September 1997 - August 2000

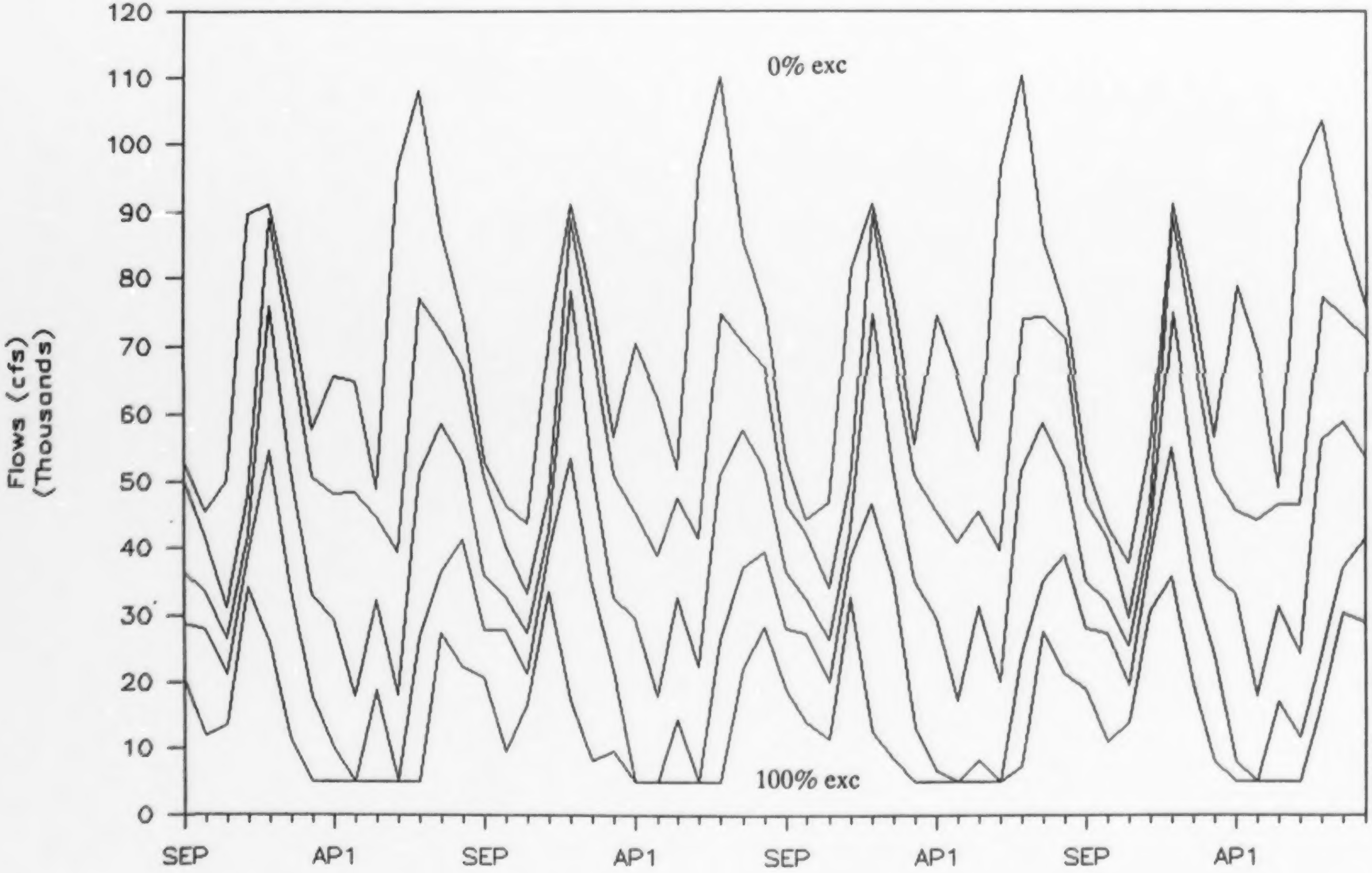


Figure A9.1.19 Flows at Arrow Lakes Reservoir, Base Case (AOS): September 2001 - August 2004

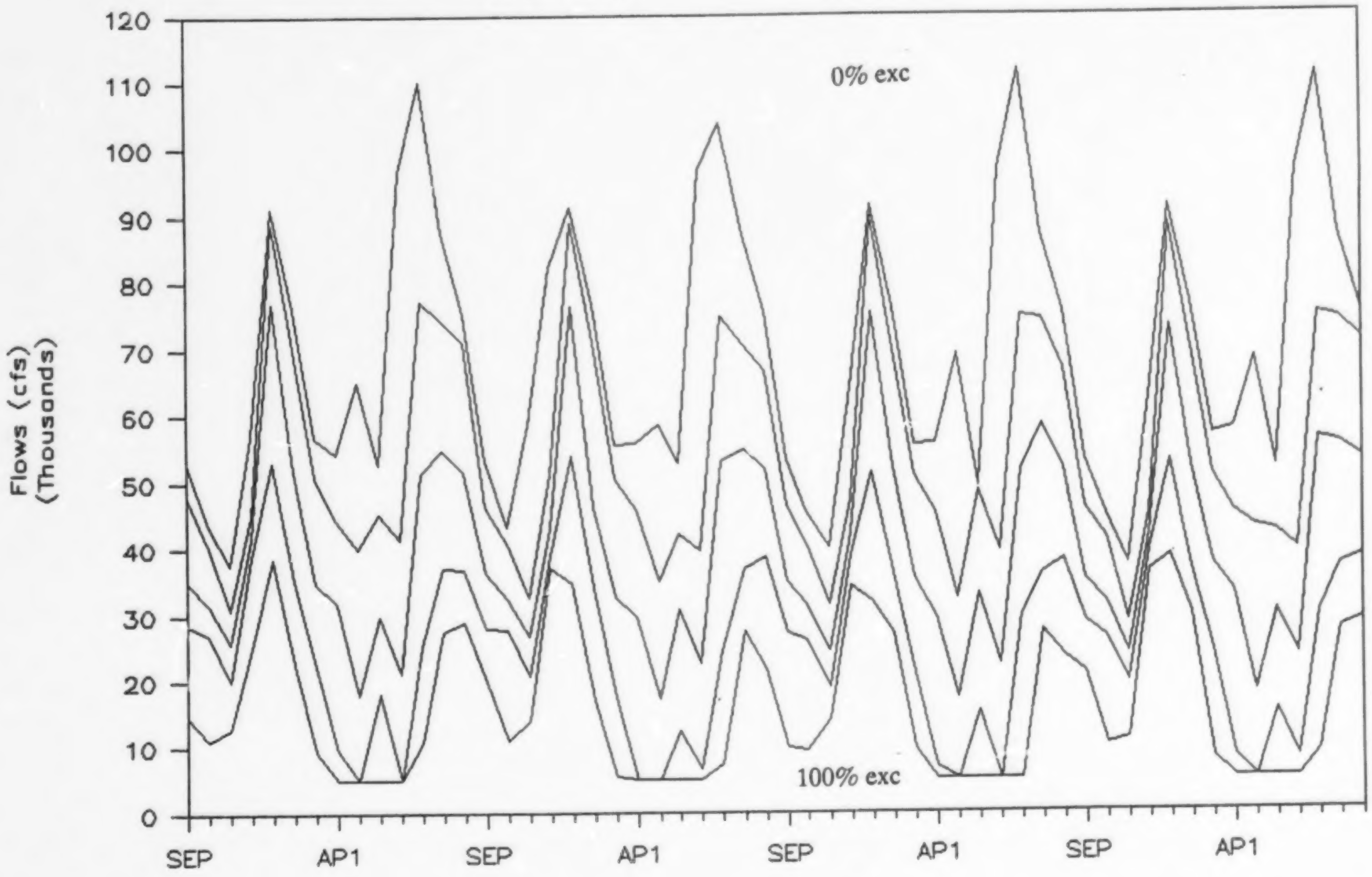
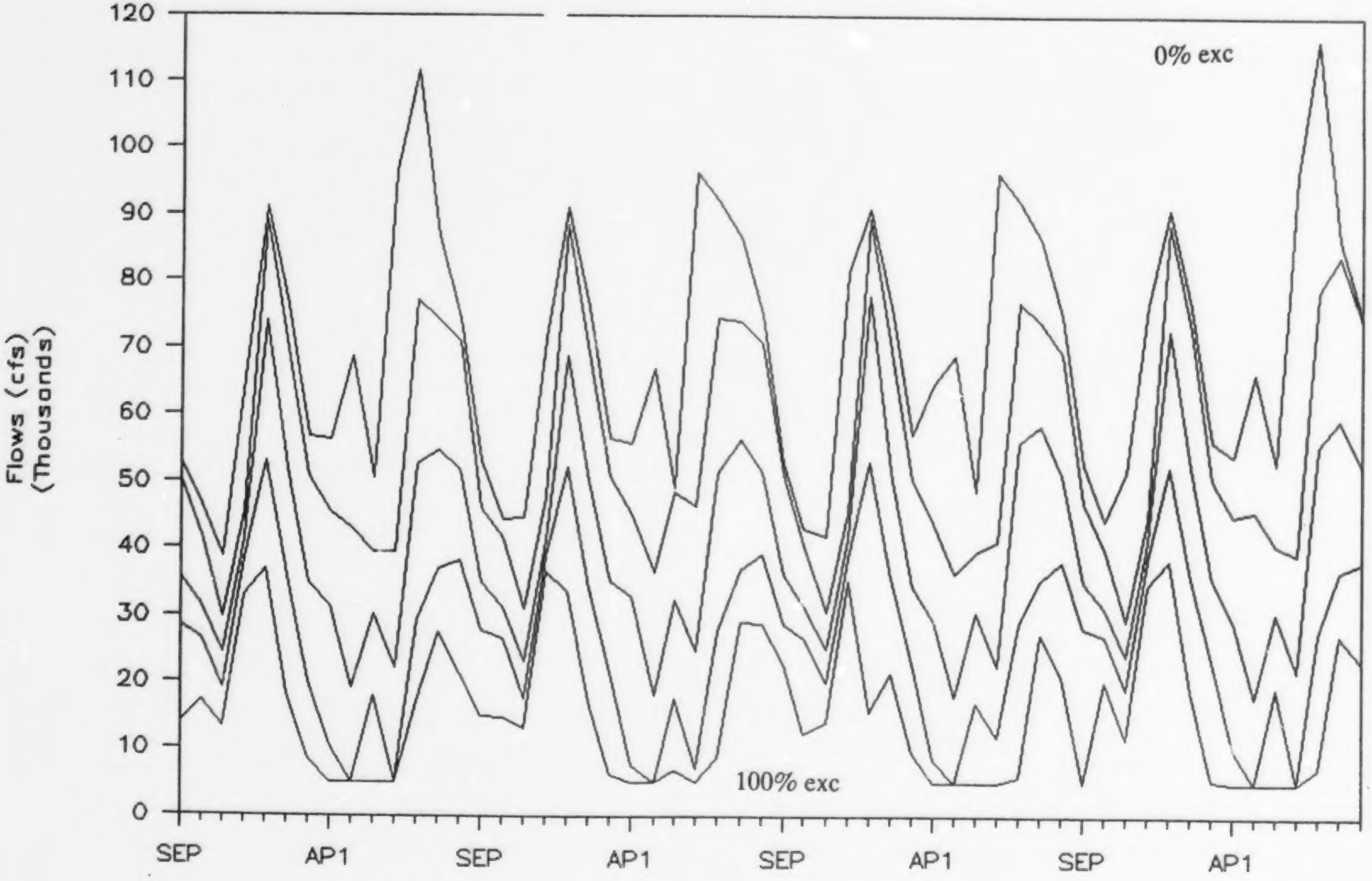


Figure A9.1.20 Flows at Arrow Lakes Reservoir, Base Case (AOS): September 2005 - August 2008



APPENDIX 9.2

Regime 1 (AOS)

Figure A9.2.1 Elevations at Mica Reservoir, Regime 1 (AOS): September 1989 - August 1992

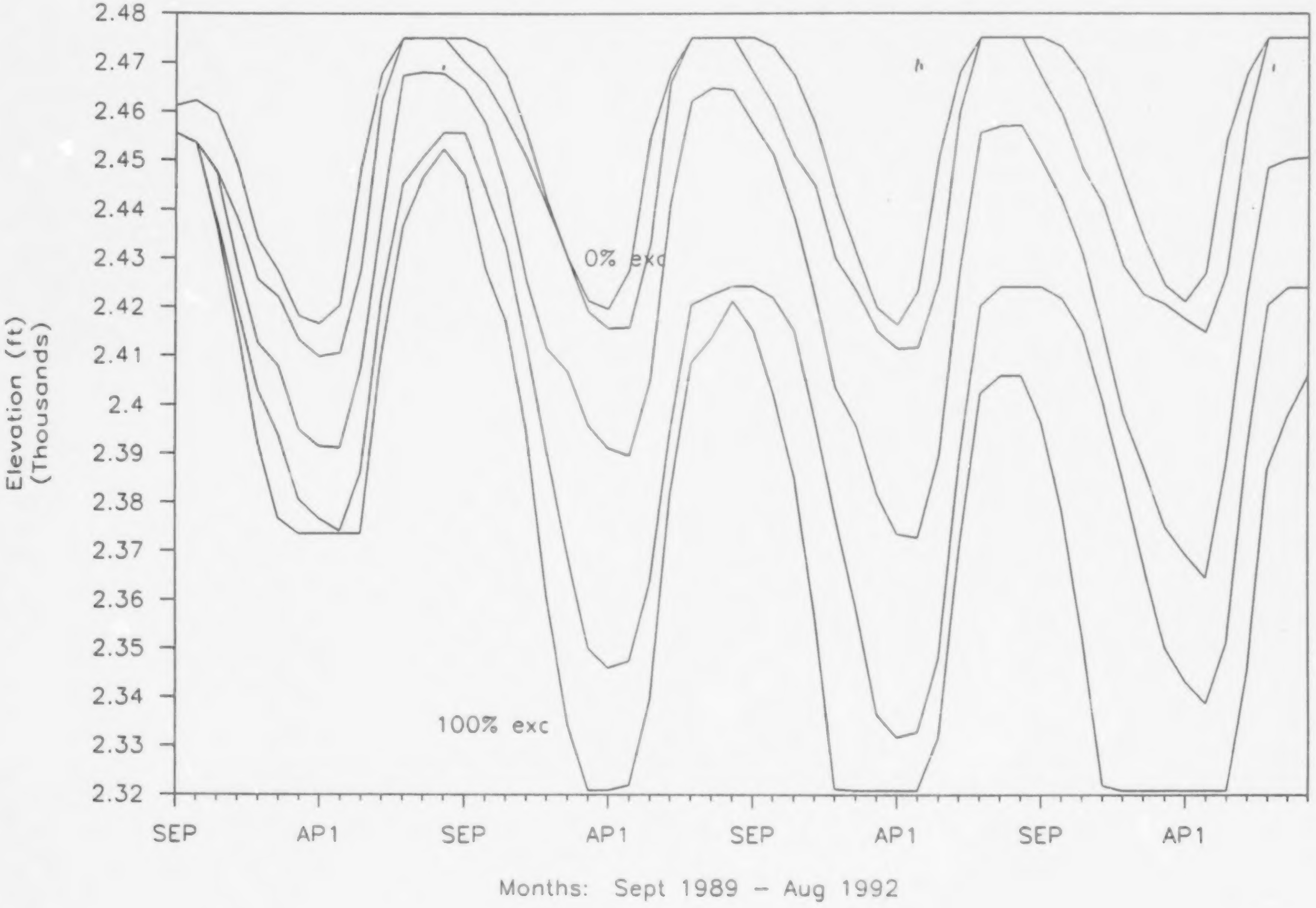


Figure A9.2.2 Elevations at Mica Reservoir, Regime 1 (AOS): September 1993 - August 1996

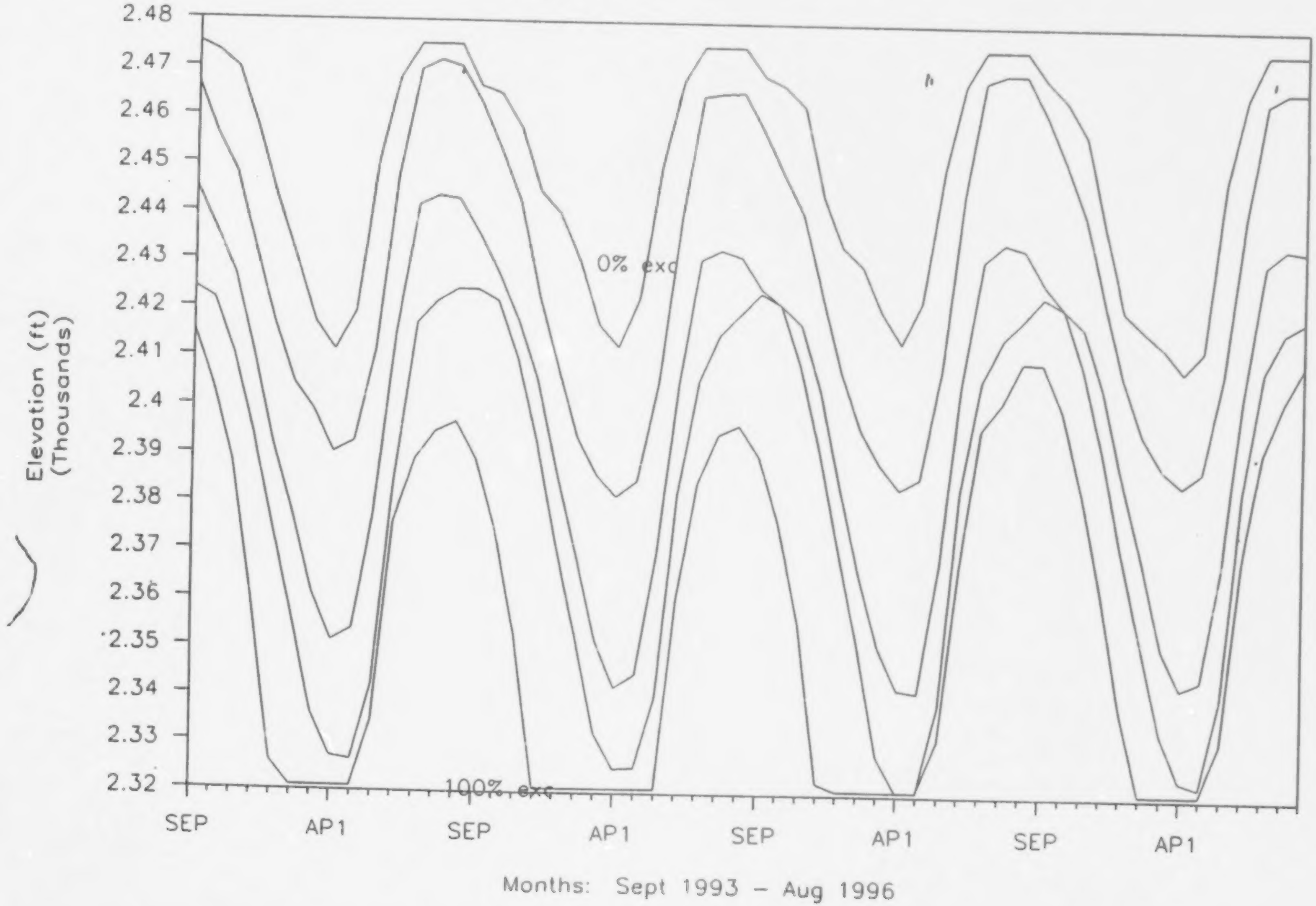


Figure A9.2.3 Elevations at Mica Reservoir, Regime 1 (AOS): September 1997 - August 2000

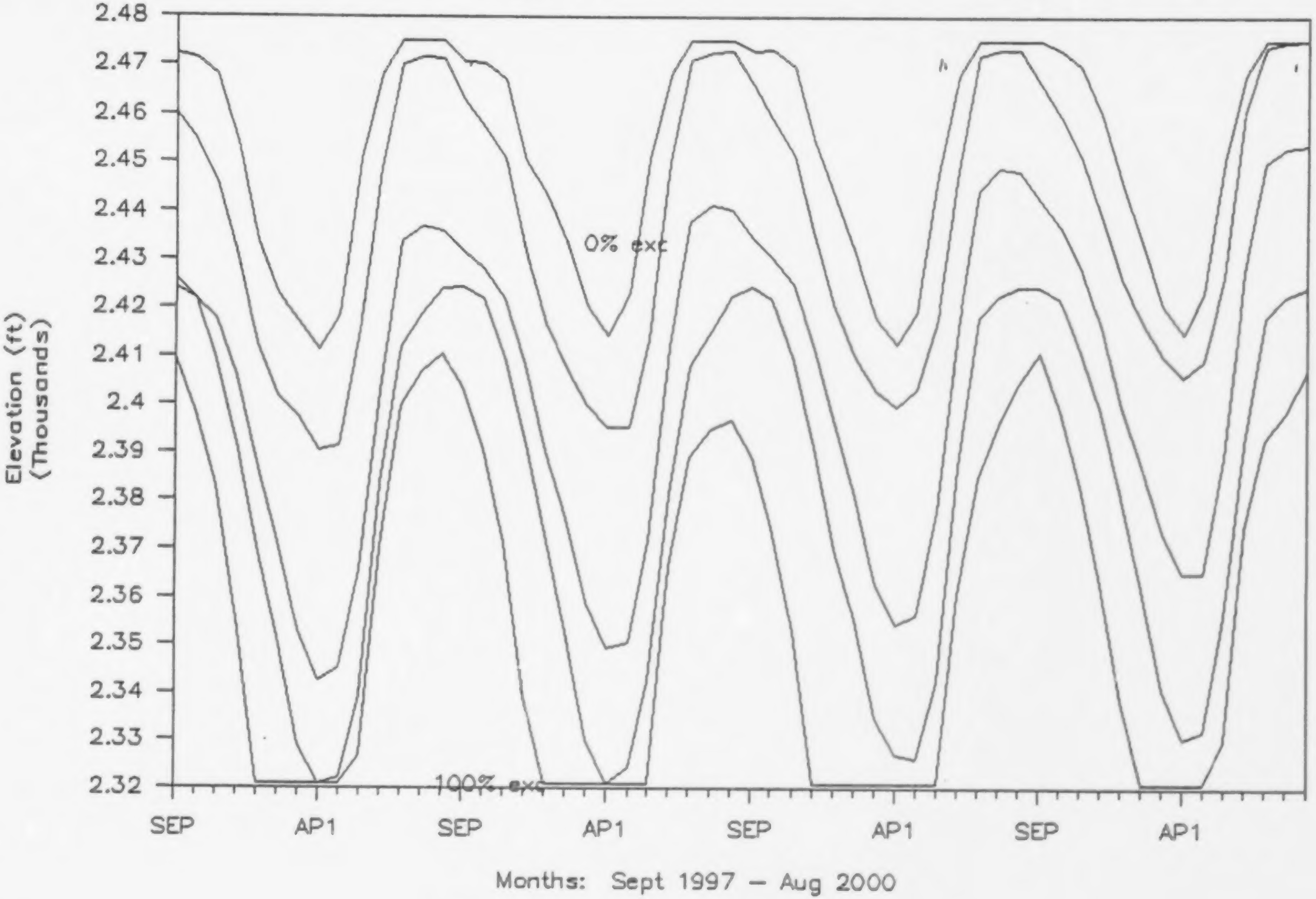


Figure A9.2.4 Elevations at Mica Reservoir, Regime 1 (AOS): September 2001 - August 2004

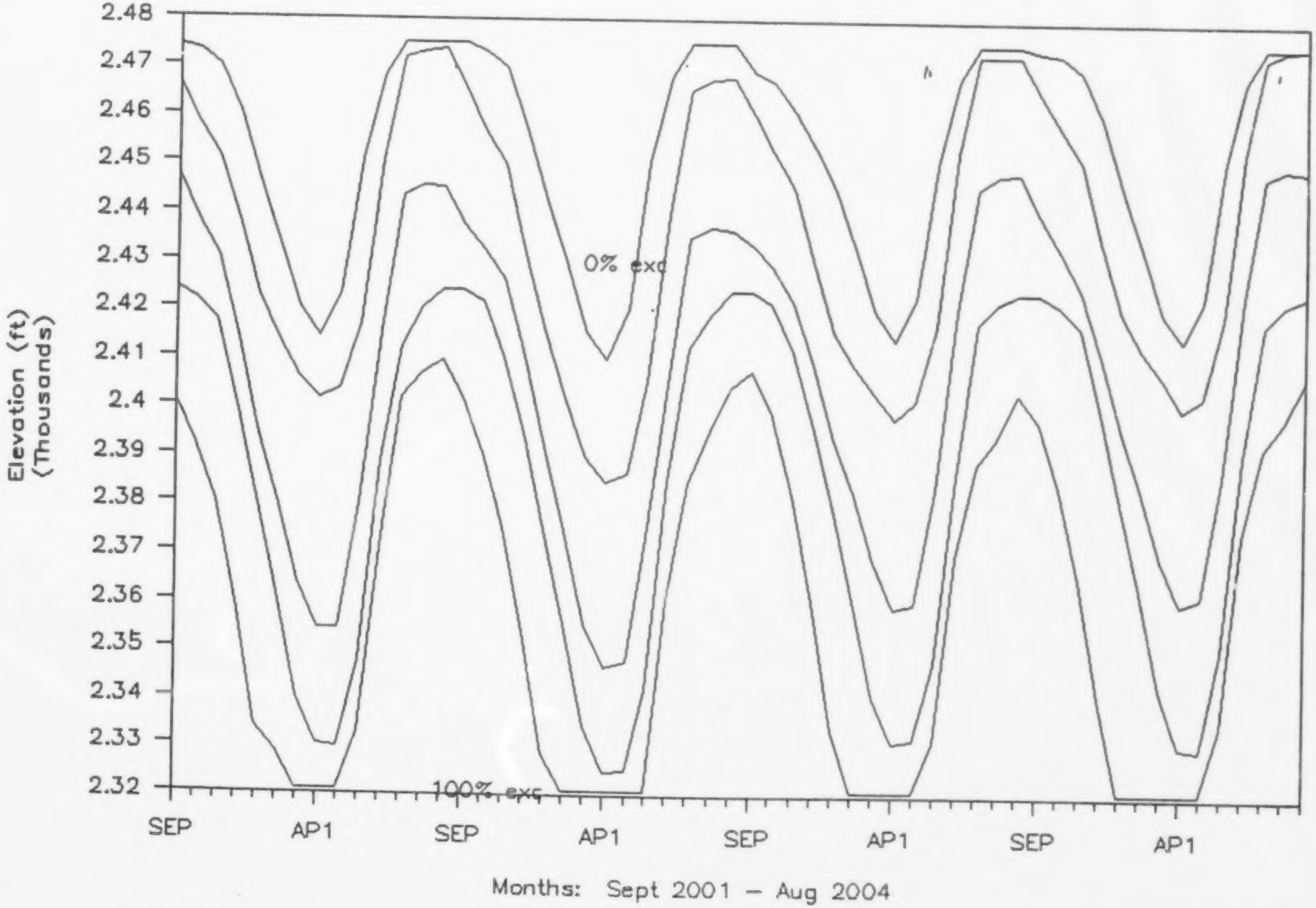


Figure A9.2.5 Elevations at Mica Reservoir, Regime 1 (AOS): September 2005 - August 2008

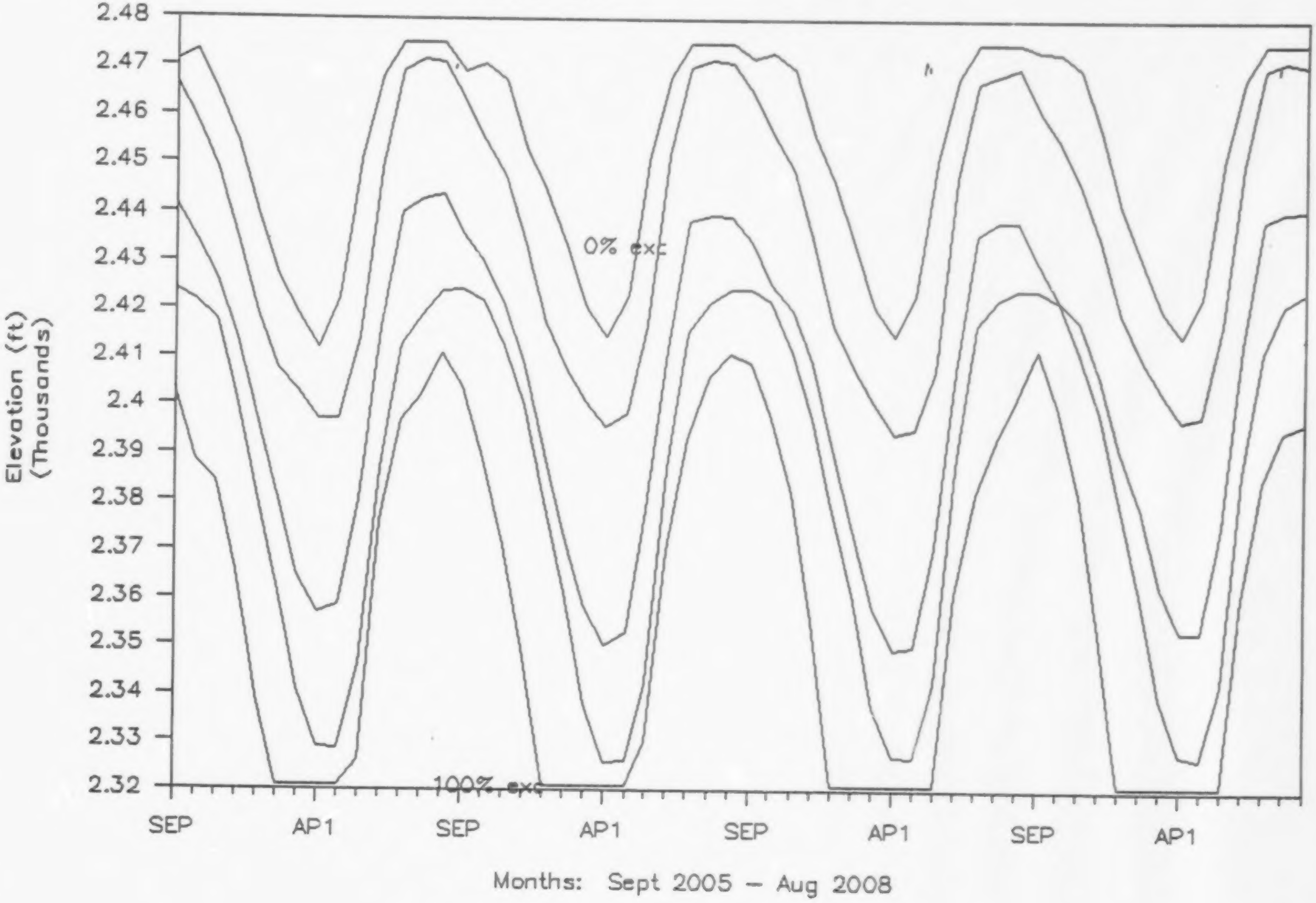


Figure A9.2.6 Flows at Mica Reservoir, Regime 1 (AOS): September 1989 - August 1992

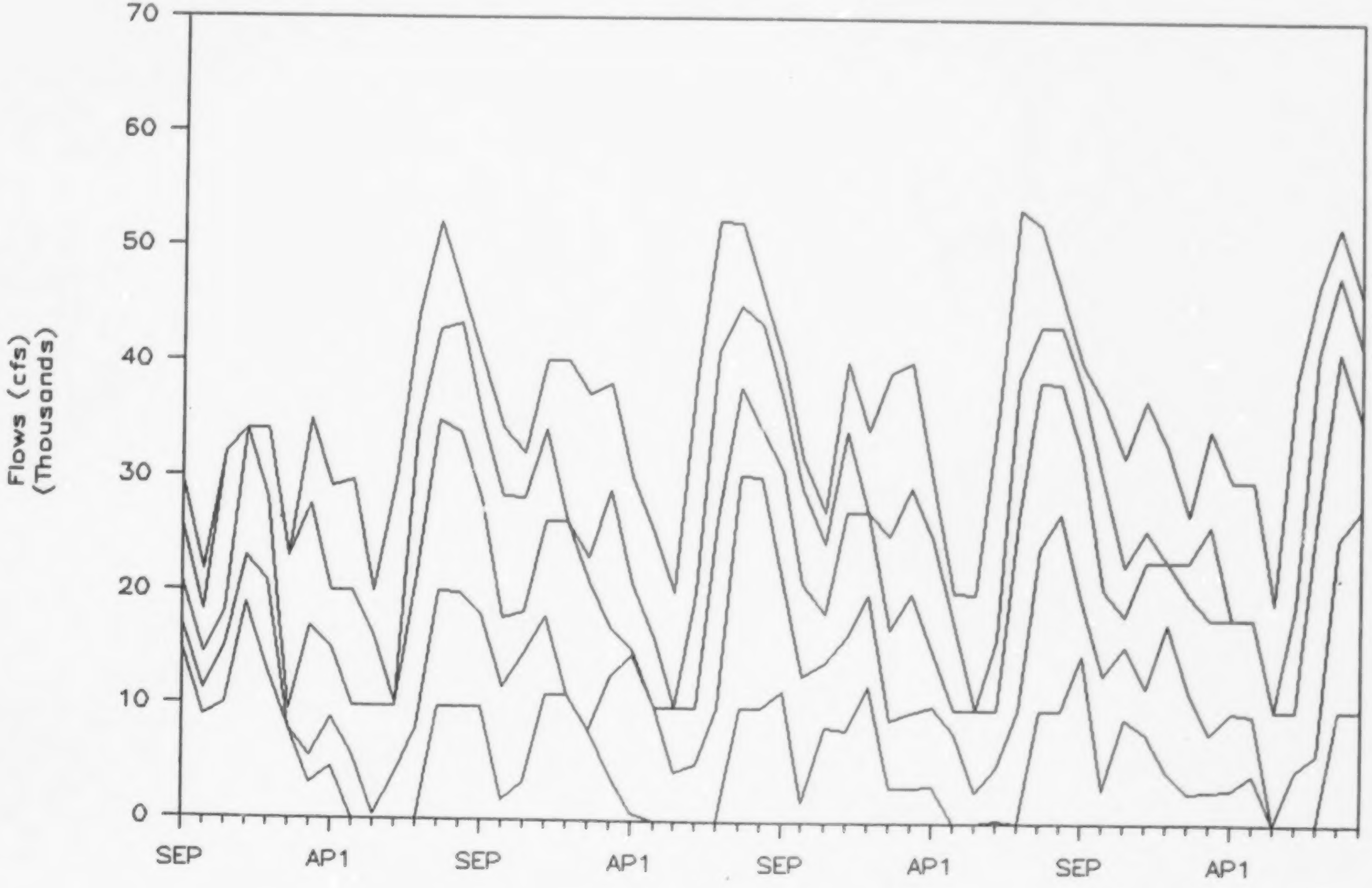


Figure A9.2.7 Flows at Mica Reservoir, Regime 1 (AOS): September 1993 - August 1996

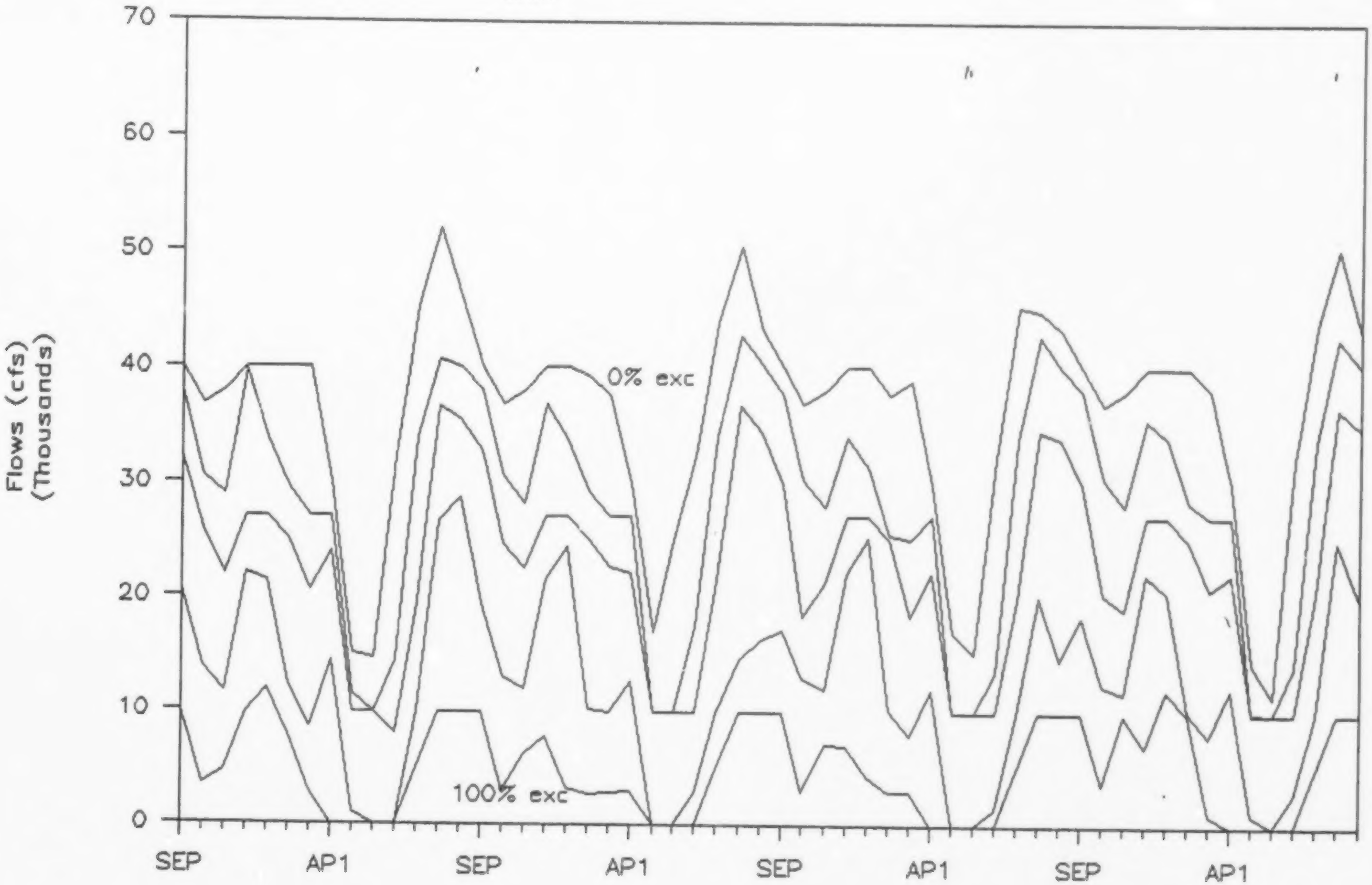


Figure A9.2.8 Flows at Mica Reservoir, Regime 1 (AOS): September 1997 - August 2000

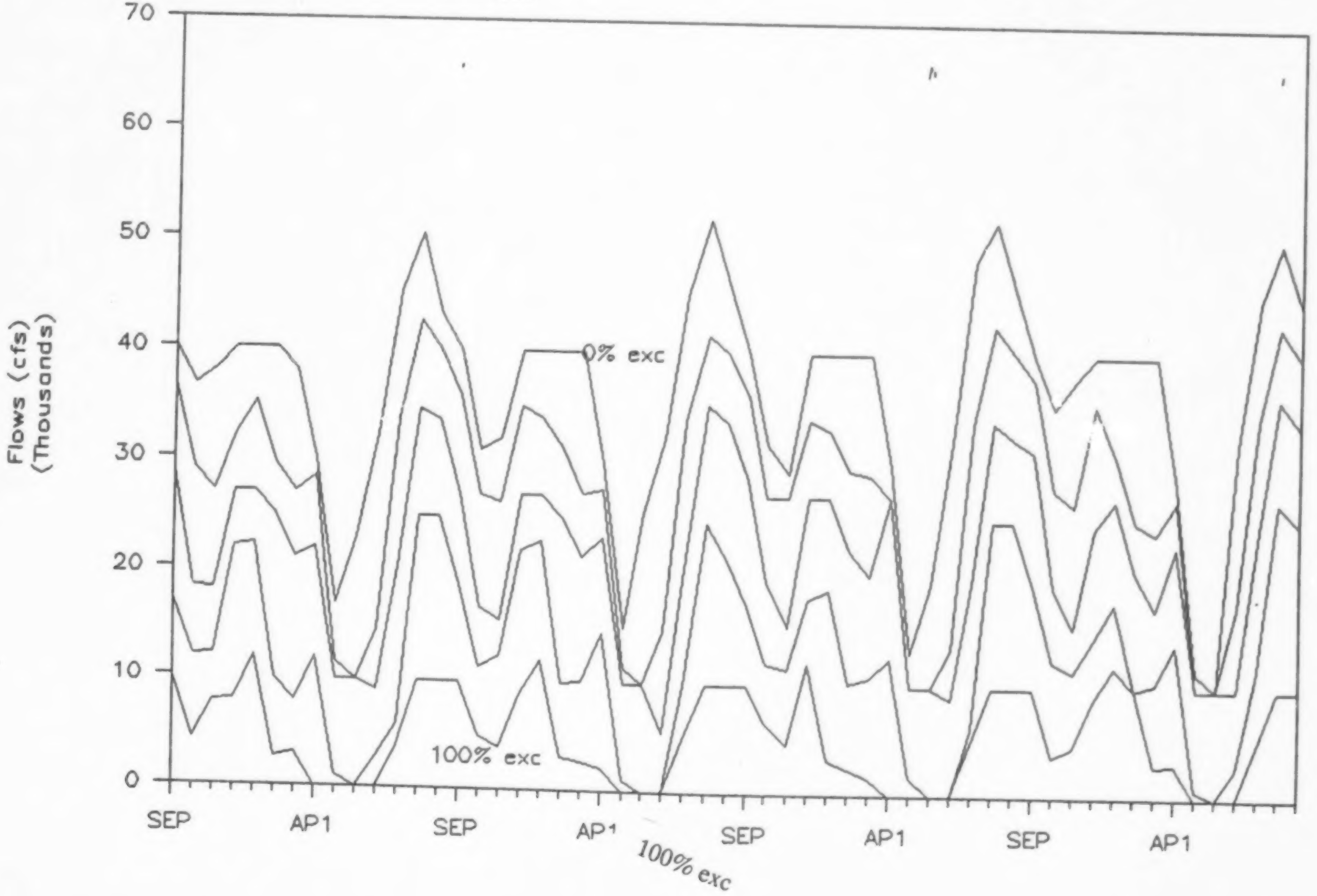


Figure A9.2.9 Flows at Mica Reservoir, Regime 1 (AOS): September 2001 - August 2004

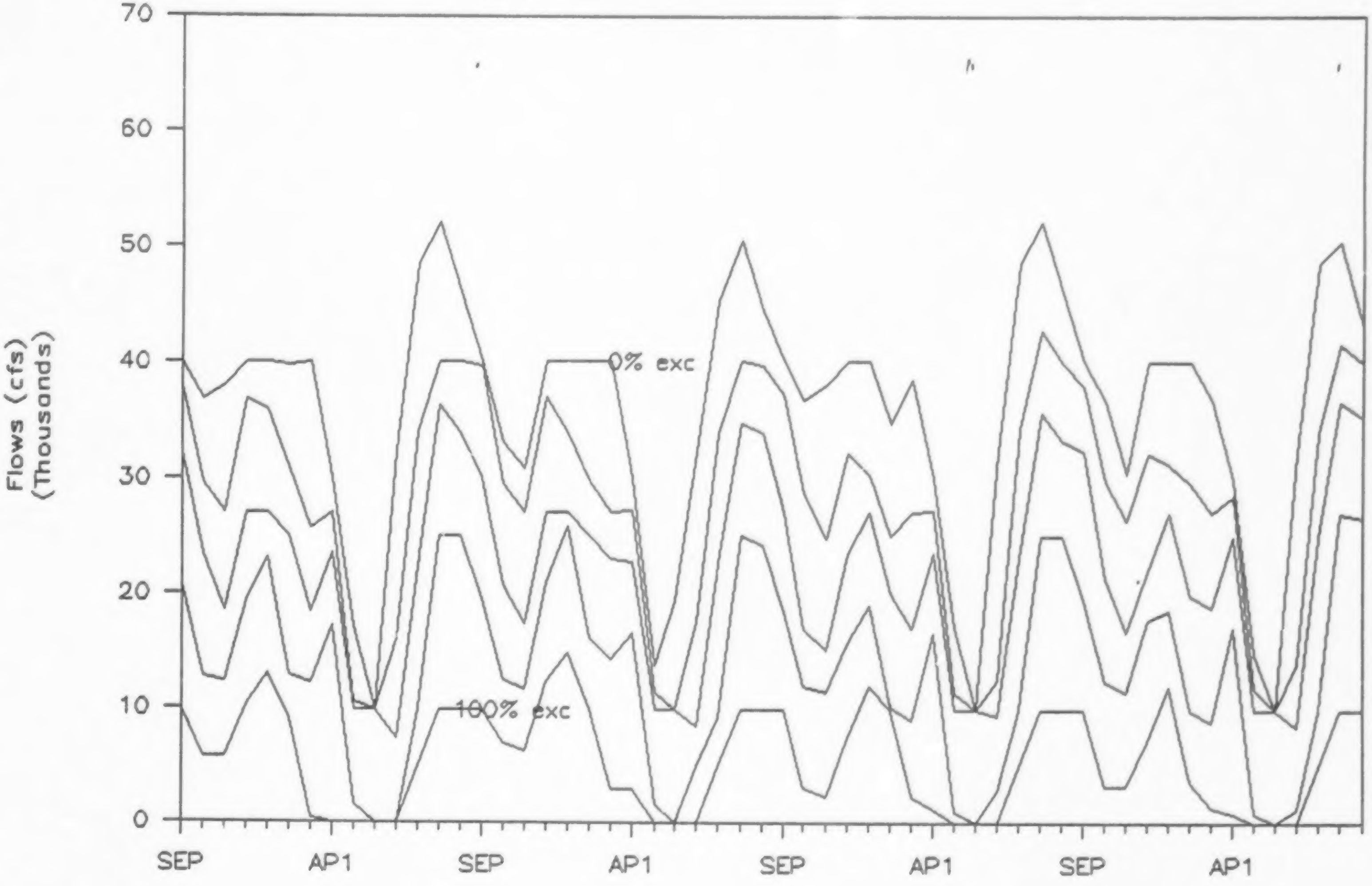


Figure A9.2.10 Flows at Mica Reservoir, Regime 1 (AOS): September 2005 - August 2008

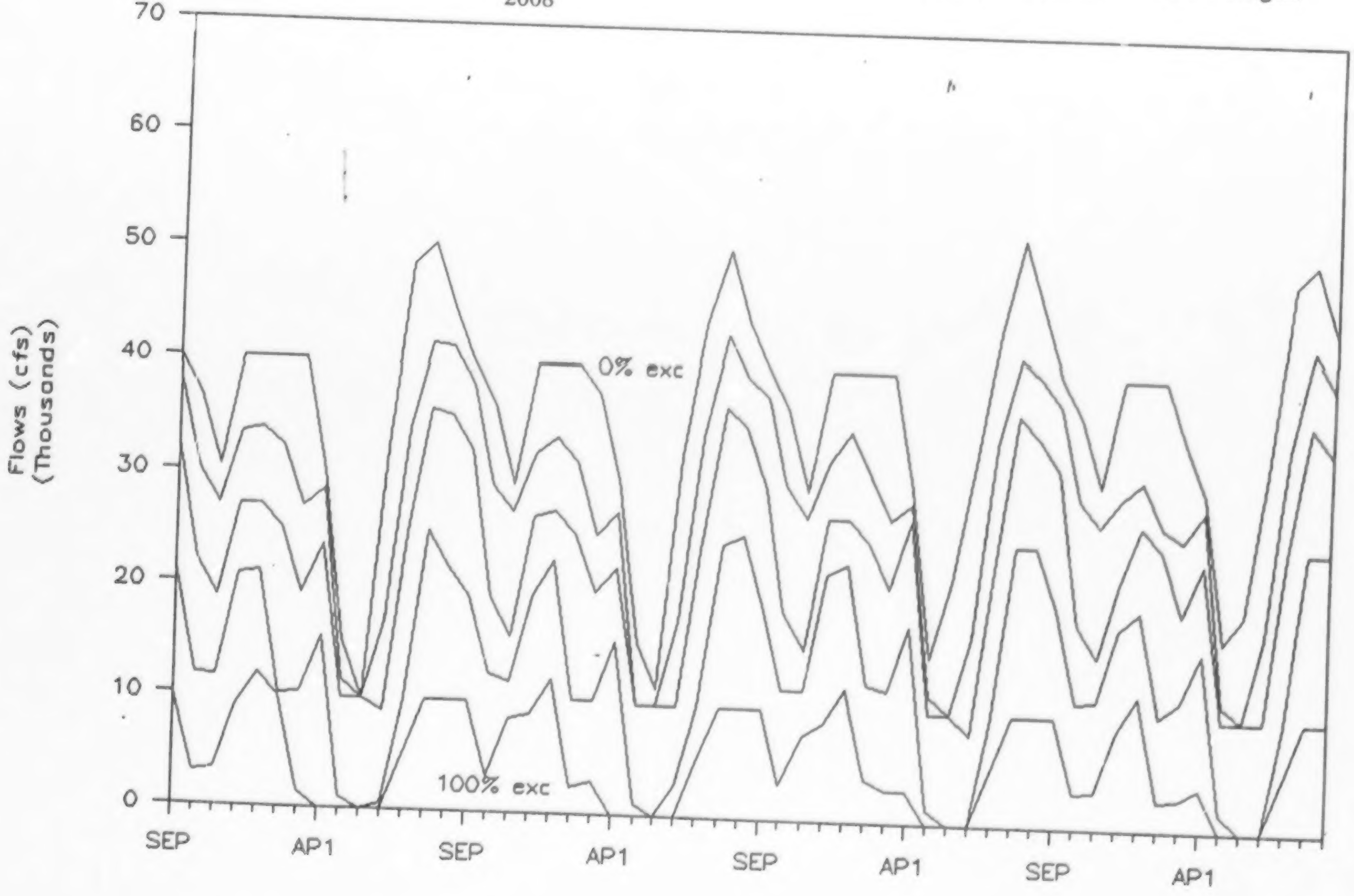


Figure A9.2.11 Elevations at Arrow Lakes Reservoir, Regime 1 (AOS): September 1989 - August 1992

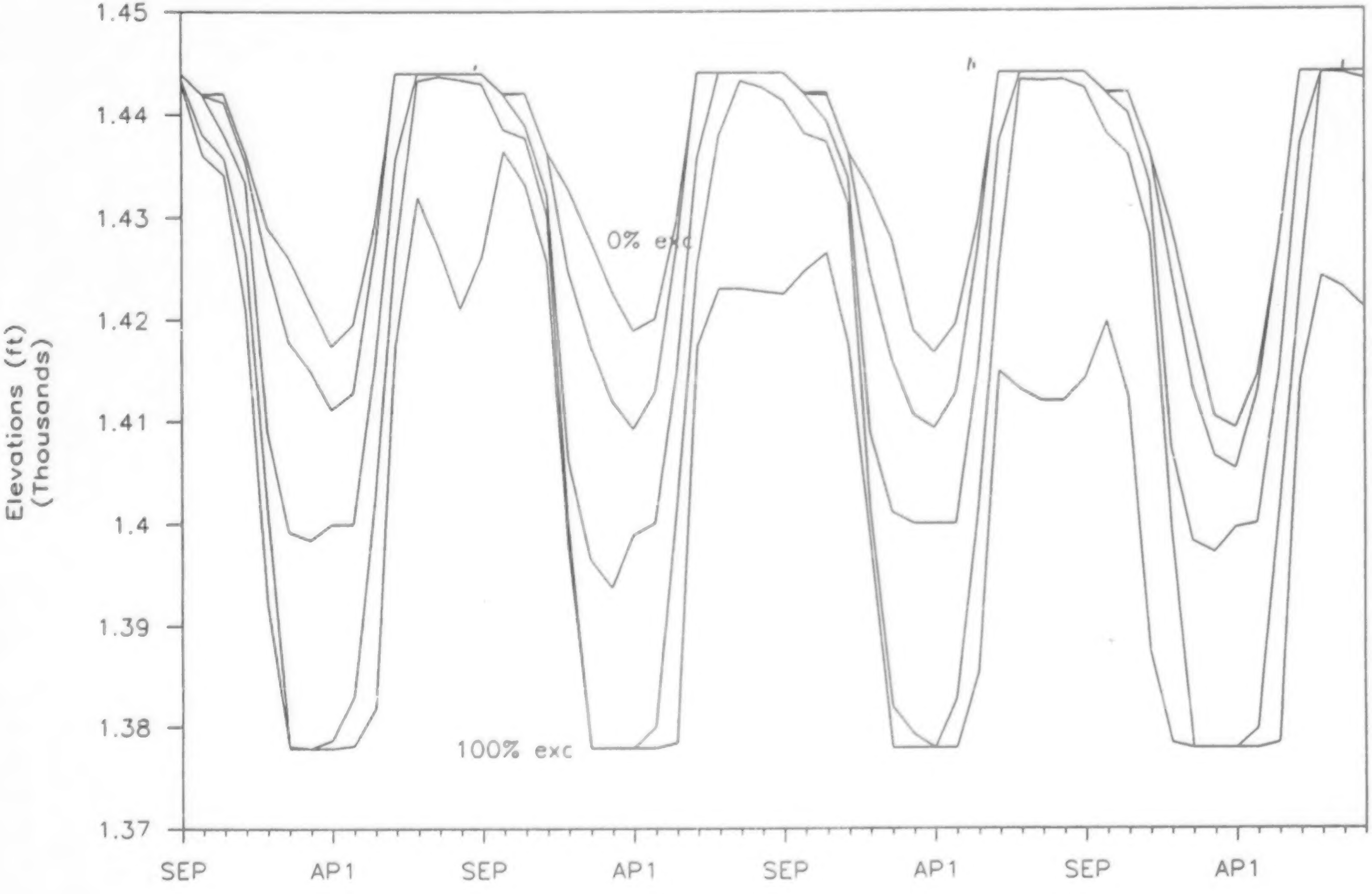


Figure A9.2.12 Elevations at Arrow Lakes Reservoir, Regime 1 (AOS): September 1993 - August 1996

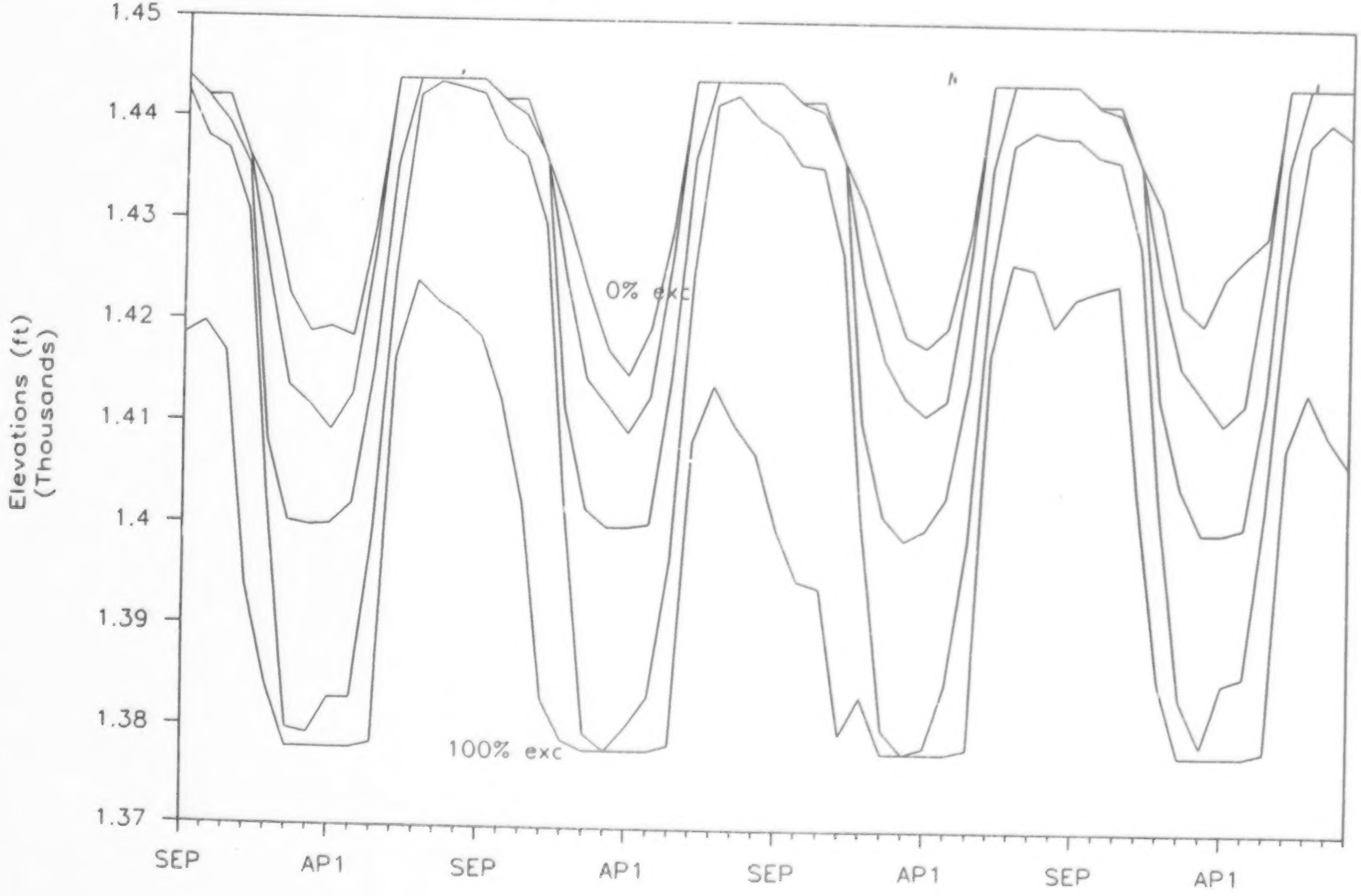


Figure A9.2.13 Elevations at Arrow Lakes Reservoir, Regime 1 (AOS): September 1997 - August 2000

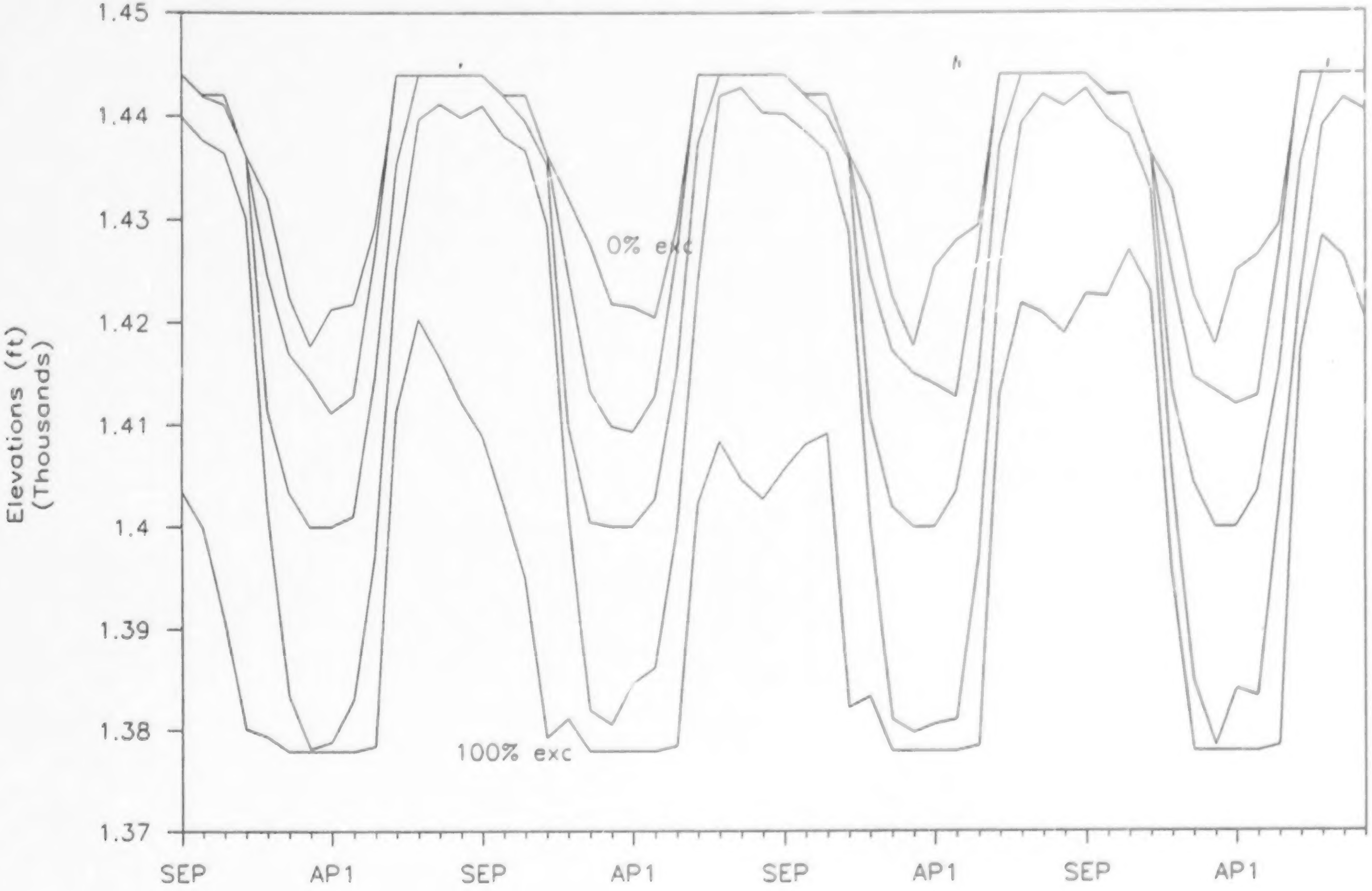


Figure A9.2.14 Elevations at Arrow Lakes Reservoir, Regime 1 (AOS): September 2001 - August 2004

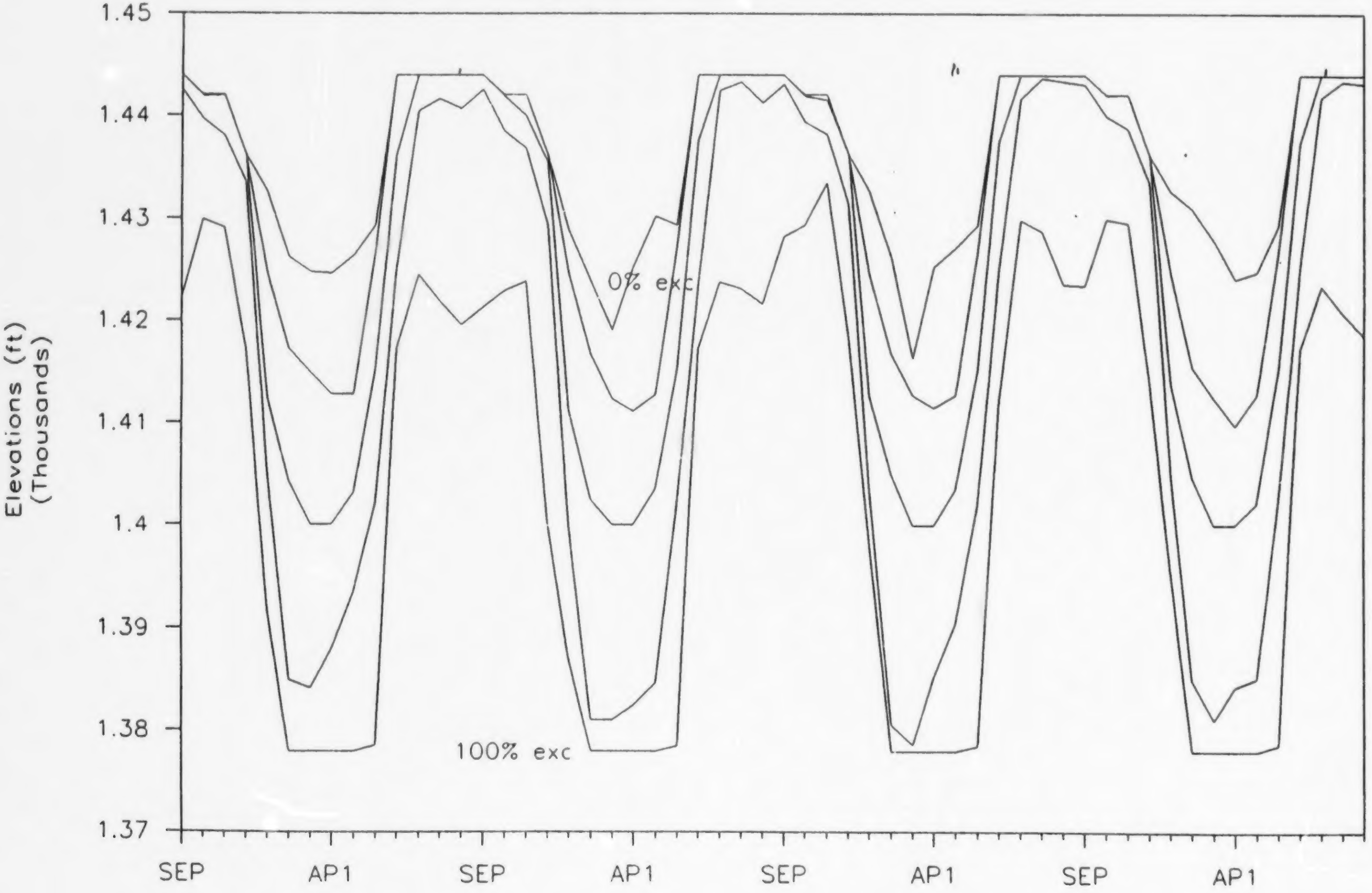


Figure A9.2.15 Elevations at Arrow Lakes Reservoir, Regime 1 (AOS): September 2005 - August 2008

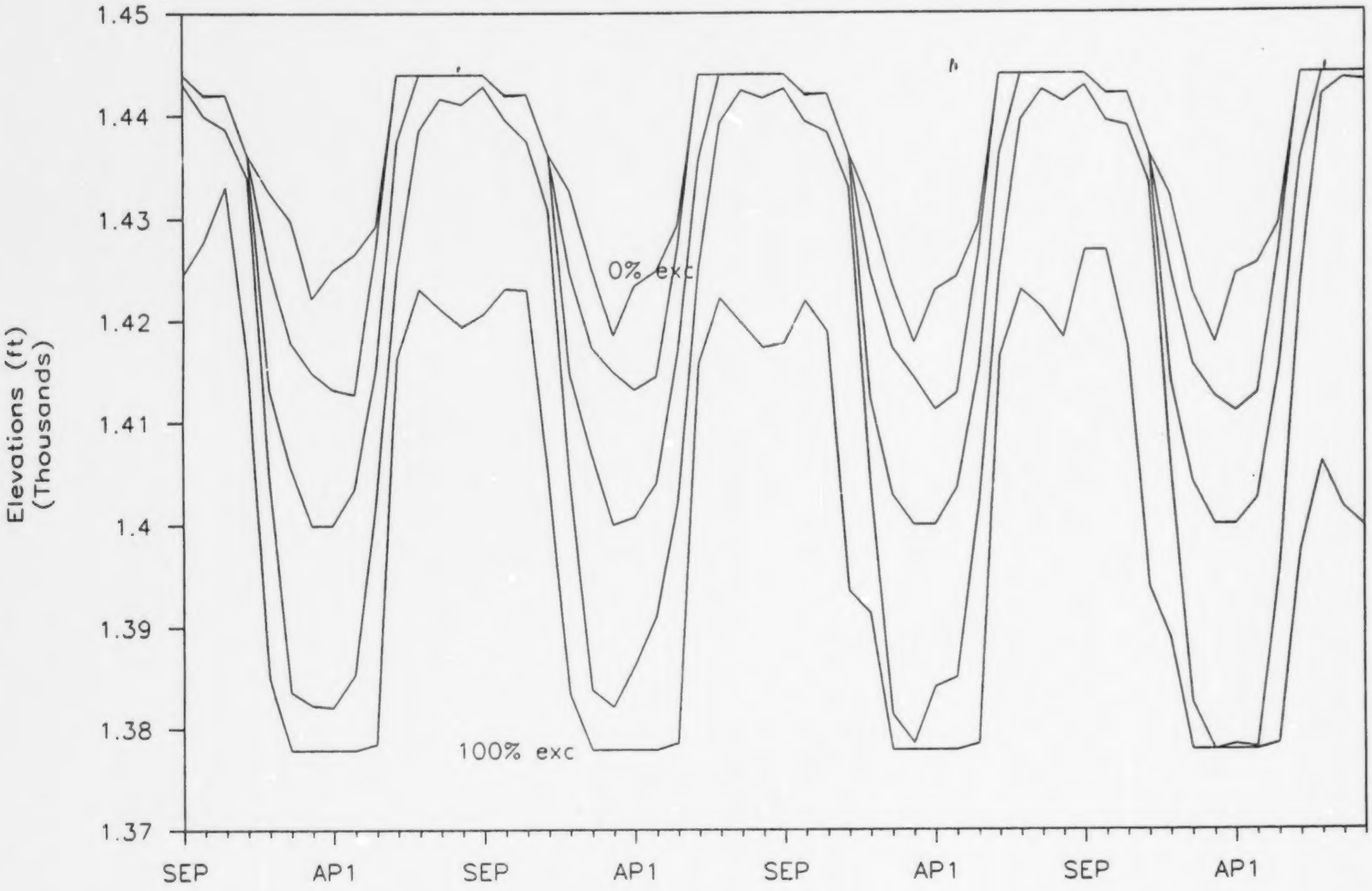


Figure A9.2.16 Flows at Arrow Lakes Reservoir, Regime 1 (AOS): September 1989 - August 1992

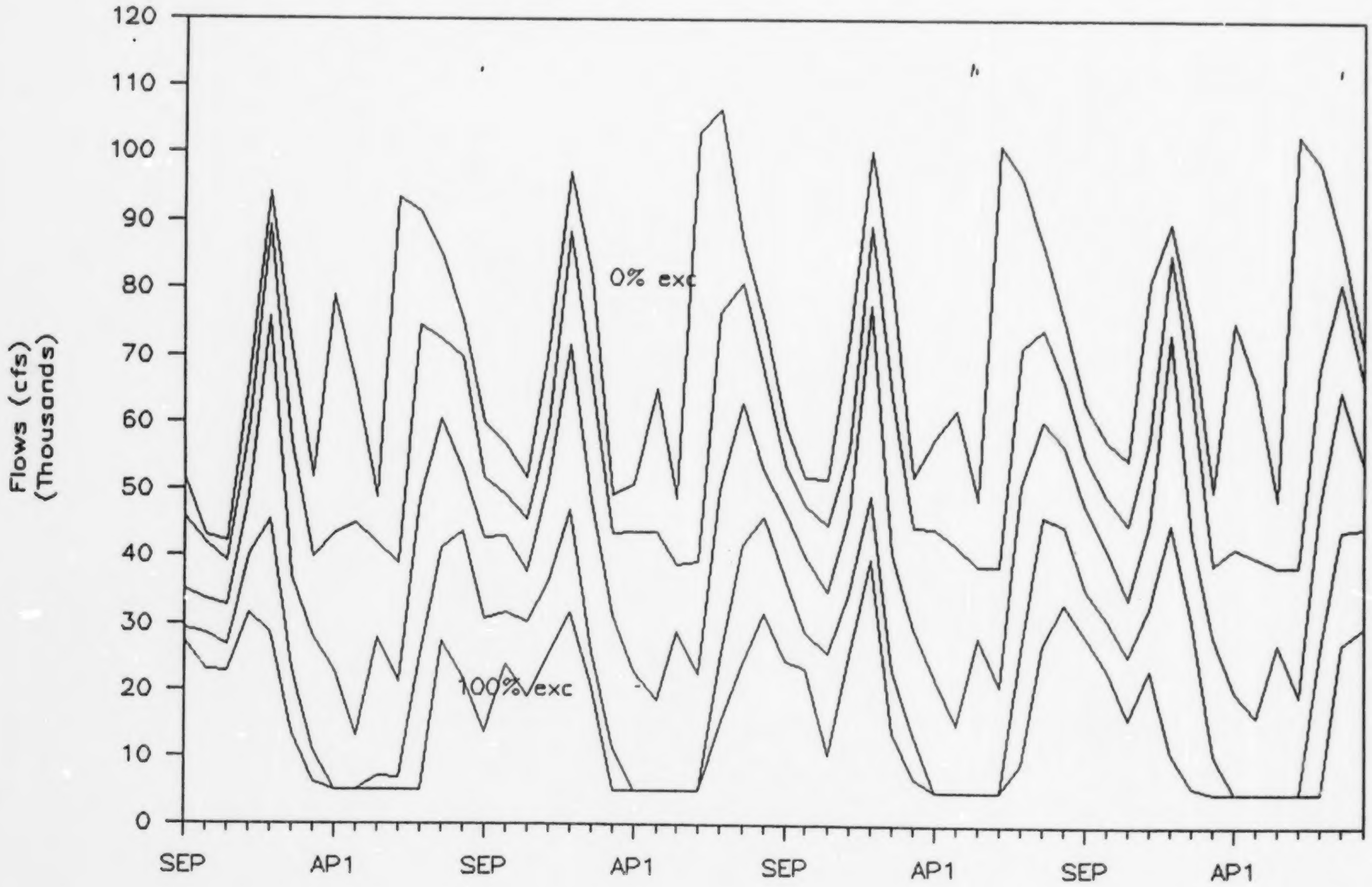


Figure A9.2.17 Flows at Arrow Lakes Reservoir, Regime 1 (AOS): September 1993 - August 1996

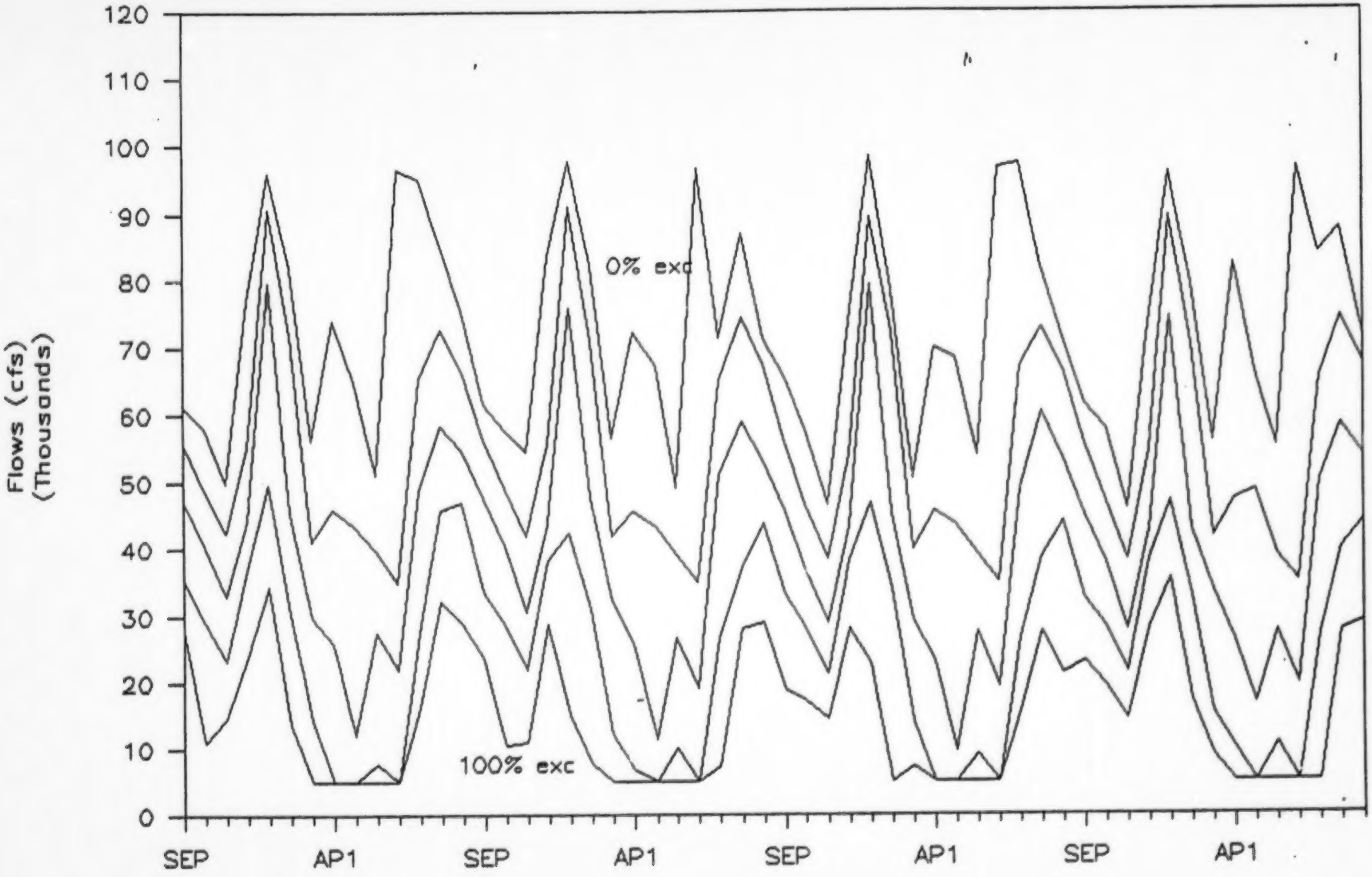


Figure A9.2.18 Flows at Arrow Lakes Reservoir, Regime 1 (AOS): September 1997 - August 2000

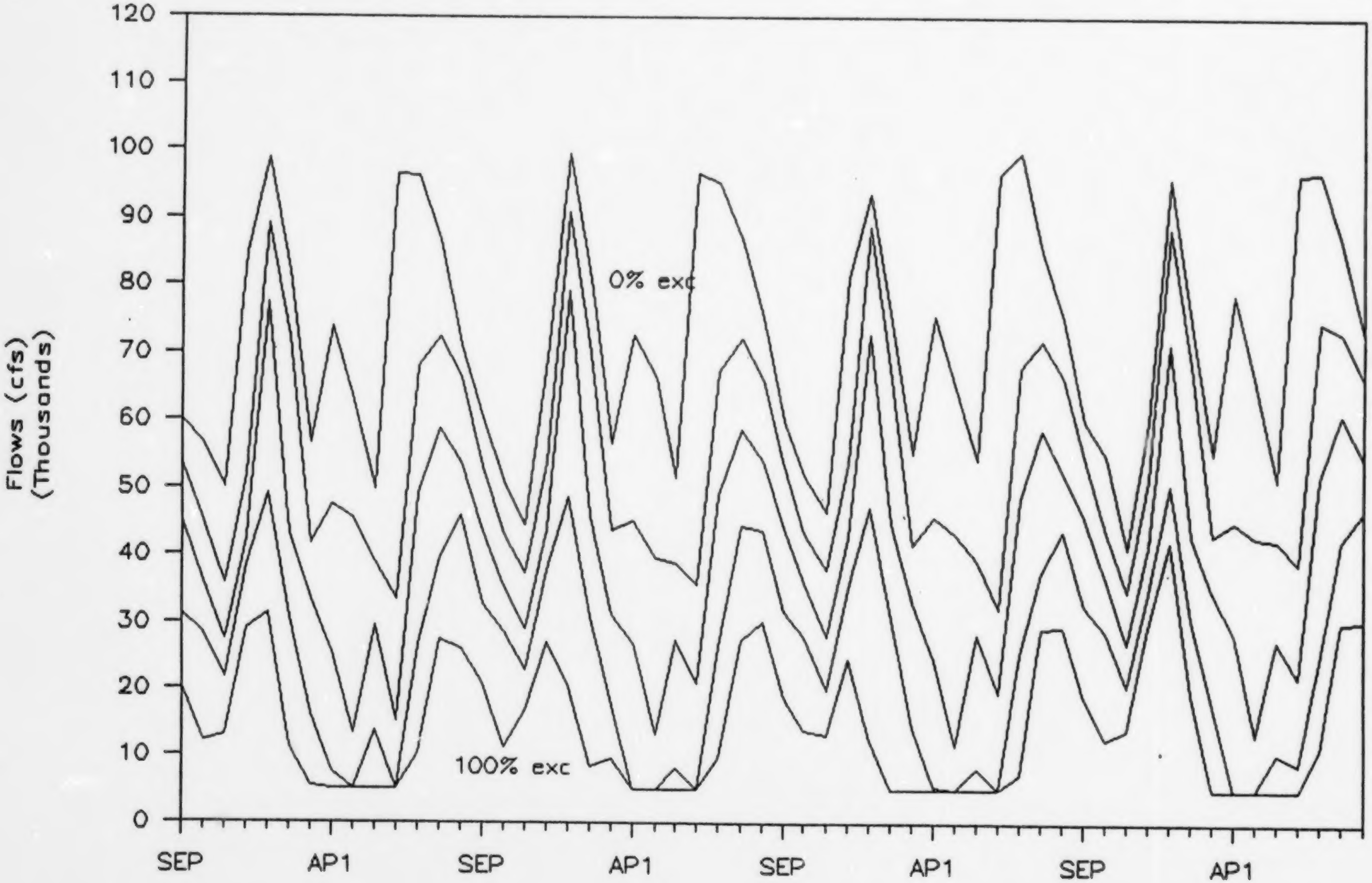


Figure A9.2.19 Flows at Arrow Lakes Reservoir, Regime 1 (AOS): September 2001 - August 2004

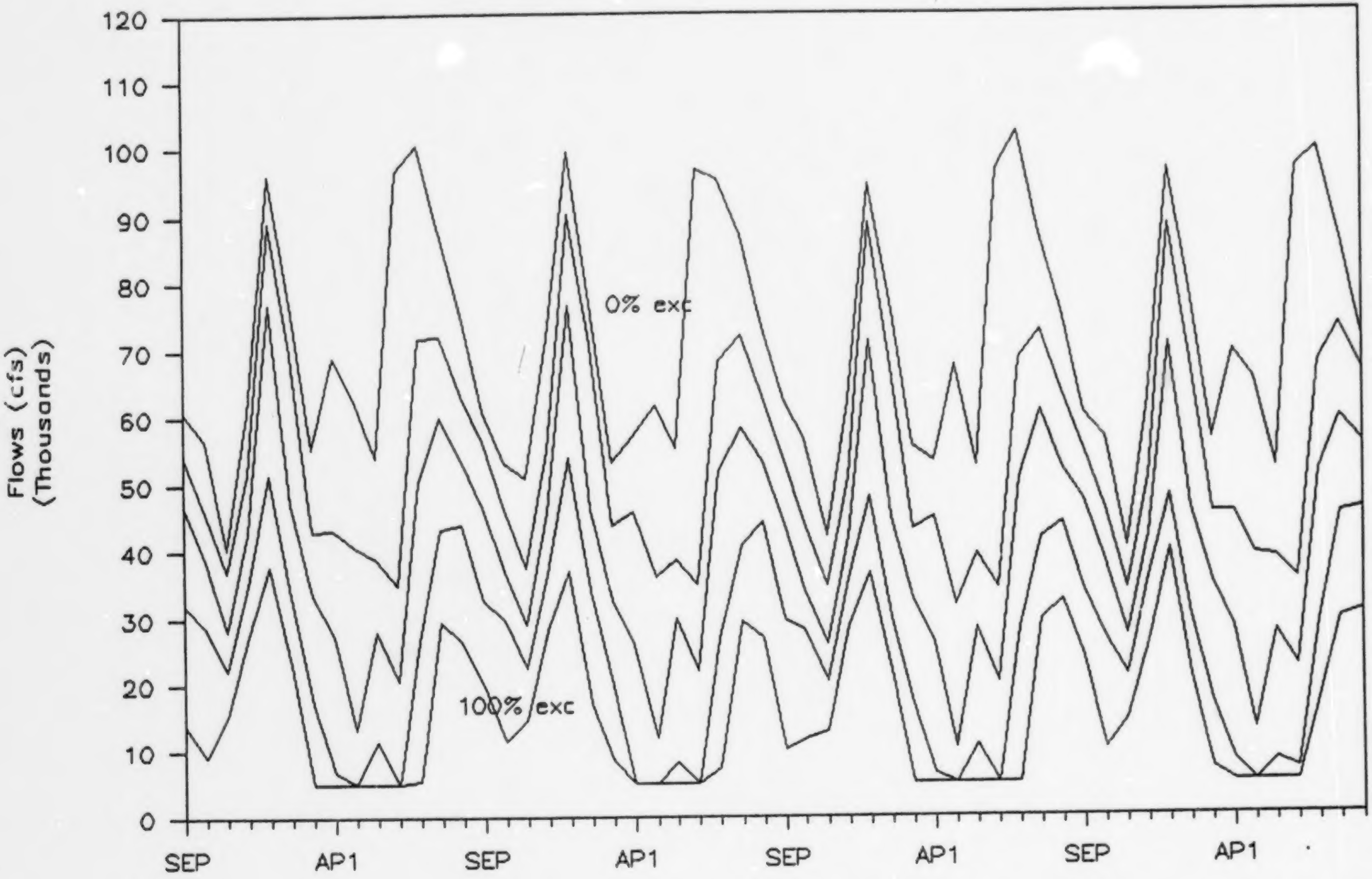


Figure A9.2.20 Flows at Arrow Lakes Reservoir, Regime 1 (AOS): September 2005 - August 2008